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Topography Experiment (TOPEX) Software Document Series, Volume 21

TOPEX Radar Altimeter Engineering Assessment Report Final Update—Side B Turn-On to End-of-Mission on October 9, 2005

D.W. Lockwood, D.W. Hancock, III, G.S. Hayne, and R.L. Brooks

July 2006

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About the Series

The TOPEX Radar Altimeter Technical Memorandum Series is a collection of performance assessment documents produced by the NASA Goddard Space Flight Wallops Flight Facility over a period starting prior to the TOPEX launch in 1992 and continuing over the greater than 13 year TOPEX lifetime to the end-of-mission in 2005. Because of the mission's success over this long period and because the data are being used internationally to redefine many aspects of ocean knowledge, it is important to make a permanent record of the TOPEX radar altimeter performance assessments which were originally provided to the TOPEX project over the life of the mission. The original reports are being printed in this series without change to make the information more publicly available as the original investigators become less available to explain the altimeter operation and the details of the various data anomalies that have been resolved. (See Appendix J.)

Foreword

The Engineering Assessment of the TOPEX Radar Altimeter is performed on a continuing basis by the TOPEX Altimeter Team at NASA/GSFC Wallops Flight Facility. The Assessment Team members are:

David W. Hancock III/NASA: TOPEX Altimeter Verification Manager/Team Leader
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Annette M. Conger/SGT, Inc.
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For the latest updates on the performance of the TOPEX Radar Altimeter, and for accessing many of our reports, readers are encouraged to contact our WFF/TOPEX Home Page at http://topex.wff.nasa.gov.

For additional information on this topic, please contact the Team Leader, David W. Hancock III. He may be reached at 757-824-1238 (Voice), 757-824-1036 (FAX), or by e-mail at David.W.Hancock@nasa.gov.

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Section 1

Introduction

1.1 Identification of Document

This is the thirteenth and final report in a series of TOPEX Radar Altimeter Engineering Assessment Reports.

The initial TOPEX Radar Altimeter Engineering Assessment Report, in February 1994, presented performance results for the NASA Radar Altimeter on the TOPEX/POSEIDON spacecraft, from the time of its launch in August 1992 to February 1994. Since the time of that initial report and prior to this report, there have been eleven interim supplemental Engineering Assessment Reports, issued in March 1995, May 1996, March 1997, June 1998, August 1999, September 2000, June 2001, March 2002, May 2003, April 2004 and again in September 2005.

The sixth supplement in September 2000 was the first assessment report that addressed Side B performance, and presented the altimeter performance from the turn-on of Side B until the end of calendar year 1999. This report extends the performance assessment of Side B to the final collection of data on October 9, 2005, and includes the performance assessment of Jason-1, the TOPEX follow-on mission, launched on December 7, 2001. This report provides some comparisons of Side A and Side B performance.

Over the years since TOPEX/POSEIDON launch, we have performed a variety of TOPEX performance studies; Appendix A provides an accumulative index of those studies. As the performance database has expanded, and as analysis tools and techniques continue to evolve, the longer-term trends of the altimeter data have become more apparent. The updated and final findings are presented here.

Section 2

On-Orbit Instrument Performance (Cycles 453 through Partial Cycle 481)

From the time of the initial turn-on of Side B on February 10, 1999, to the final data collection on October 9, 2005, the NASA Radar Altimeter was in TRACK mode for a total of approximately 55,750 hours. The altimeter was in IDLE mode for an additional 1880 hours, generally due to the French Altimeter's being turned on. The French Altimeter was turned on only once since January 23, 2001; that was during cycle 361 (2002-183 to 2002-193).

The NASA altimeter has been OFF for a total of 468 hours, attributable to: a 16-hour spacecraft level safehold on August 31, 1999; a related 8-hour OFF status three days later to switch the spacecraft attitude control electronics on September 3, 1999; a 27-hour spacecraft level safehold on November 24, 2000, and two spacecraft safeholds totaling 417 hours in 2004. In 2004, the two spacecraft level safeholds were due to pitch reaction wheel failure: a 392-hour safehold on May 26, 2004; and a 25-hour safehold on December 17, 2004.

As reported in the *TOPEX Engineering Assessment Report Update*, NASA/TM-2005-212236/Volume 19, a significant change in data collection occurred on August 8, 2004; when the last of the three onboard tape recorders was decommissioned due to aging effects. Since then, data collection was accomplished using exclusively TDRSS. The use of solely TDRSS had two primary effects on TOPEX data collection: (1) the number of hours per day of data decreased and (2) geographically-correlated gaps in TDRSS data collection impacted cycle-averages of sea surface height and significant wave height.

After the Jason-1 launch on December 7, 2001, TOPEX flew in tandem with Jason-1 for approximately 240 days with measurements separated by 73 seconds, then transferred to a new interspaced orbit. TOPEX/Poseidon was transferred to a new orbit during cycle 368 (2002-227 to 2002-259), 1282 days from Side B turn-on. To the end of the assessment period (October 9, 2005) covered by this report, TOPEX had been in the new interspaced orbit for a total of 1118 days.

The October 9, 2005 spacecraft level safehold was attributed to a pitch reaction wheel failure that was unrecoverable. While the radar altimeter continued to be capable of operation subsequent to the safehold on October 9, 2005, the failure of the pitch reaction wheel resulted in inadequate spacecraft attitude control and pointing for the altimeter to collect useful science data.

Many attempts to recover the pitch wheel were conducted after the October 9 event. Some of these were more successful than others but none led to more than a few hours of operation. After it was apparent that recovery was not reasonably possible, a plan was accepted to power on altimeter Side A for an engineering evaluation. Side A was powered on November 17, 2005 to allow warm up for 24 hours and on November 18, a calibration mode and cal sweep were executed. The Side A results are reported in Section 6.

The succeeding Section 2 sub-sections discuss:

- Side B internal calibration results
- Side B cycle summary results
- Side B key events
- Side B abnormalities

2.1 Side B Internal Calibrations

The TOPEX altimeter's internal calibration mode had two submodes designated CAL1 and CAL2. In CAL1 a portion of the transmitter output was fed back to the receiver through a digitally controlled calibration attenuator and delay line. The altimeter acquired and tracked this calibration signal for 10 seconds at each of 17 different preset calibration attenuator values; each calibration attenuator value was changed by 2 dB from its neighbor. The altimeter's CAL1 had almost the same signal path as the normal fine-track mode, except that CAL1 had a delay line, a different attenuator, and switched to select these components. The altimeter's automatic gain control (AGC) loop was active during each CAL1 step, and changes in CAL1 range and AGC were directly relatable to changes in the altimeter's fine-track range and power estimation. The AGC level of CAL1 Step 5 best represented the average level seen in normal over-ocean fine-tracking, so CAL1 Step 5 data are used in the discussions of changes in calibration mode range and power estimates in this report.

When commanded to its calibration mode, the TOPEX altimeter first entered CAL1 and then CAL2. CAL2 lasted about a minute, so the entire calibration sequence lasted about 4 minutes. Internal altimeter calibrations were scheduled twice-per-day, over land areas, at approximately 0000 UTC and 1200 UTC. Internal calibrations were also performed whenever the NASA altimeter was commanded from TRACK to IDLE for a period of tracking by the French altimeter, or from IDLE back to TRACK when tracking resumed for the NASA altimeter. The calibrations prior to and after the French altimeter operations were not constrained to land areas, and usually occurred over open ocean.

Our processing of the CAL1 range data was modified in 1994, to remove the effect of the 7.3 mm quantization; the revised method is discussed in Section 2.1.1 (page 2) of the year 1994 supplement (published in March 1995). All the calibration data since launch were processed using the revised method.

2.1.1 Range Calibrations

The change in Ku-band range, from Side B turn-on occurring on day 042 of 1999 to the end-of-mission on October 9, 2005, is plotted in Figure 2-1 "Ku-band Range CAL1 Results" on page 2-4. CAL1 steps 4 through 7 are shown in the figure. The Ku-band delta range shown in Figure 2-1 (and in the succeeding calibration plots) is calculated based on the measurement minus a reference. This calibration range plot indicates that the Side B Ku-band delta range varied only about ±1 mm from the time of its turn-on to the end-of-mission in 2005. Since day 1268 (2002-214), the Ku-band delta range had undergone irregular periods of oscillations that dipped to the -4 mm level. The cause of these oscillations is discussed in Section 3.1.2. It appears that, following the safehold on days 1931 (2004-147) through 1948 (2004-164), the average level of Ku range oscillations increased by ~2 mm.

In Figure 2-1, the >20 mm decrease at day 1247 (2002-193) is caused by bad calibration data during an anomalous altimeter switch over from SSALT to ALT. SSALT experienced an seu, which did not allow transmit power enable. This occurrence is listed in Appendix C, Table C-2 "NASA Altimeter Side B - Key Events", entry Day 2002-193.

Of the four positive (~+18 mm amplitude) Ku CAL1 data spikes in Figure 2-1, at elapsed days 480, 862, 1050, and 1722, three of them are attributable to documented improper SEU recoveries. The fourth data spike, at day 1050, is likely due to an unrecorded abnormal SEU recovery. The >20 mm spike at day 2036 is attributed to a digital filter bank interface lock-up on that date.

The change in C-band calibration range is depicted in Figure 2-2 "C-band Range CAL1 Results" on page 2-5. This plot indicates that, during the initial 200 days after turn-on, the Side B C-band range negatively drifted (i.e., became shorter) by about 8 mm. Since that time, to the end-of-mission in 2005, there was a negative drift of approximately 5 mm.

The range calibrations for 2005 are shown in greater detail in Appendix E. Range calibrations and their correction values are discussed in more detail in Section 3.1.

2.1.2 AGC Calibrations

2.1.2.1 CAL1 and CAL2

The changes in Side B Ku-band AGC since launch are shown in Figure 2-3 "Ku-band AGC CAL1 and CAL2 Results" on page 2-6. CAL1 steps 4 through 6, plus CAL2, are depicted in the figure. At approximately 210 days after turn-on, there was an apparent step-function change as the Ku AGC increased approximately 0.2 dB. Since the time of that occurrence, the Ku AGC has remained fairly steady (±0.1 dB).

The change in C-band AGC since Side B turn-on is shown in Figure 2-4 "C-band AGC CAL1 and CAL2 Results" on page 2-7. The C-band AGC has gradually decreased about 0.2 dB since turn-on.

The AGC calibrations for 2005 are shown in greater detail in Appendix F. An in-depth analysis of AGC calibrations, including the corrections applied to the ground processed data, is presented in Section 3.2.

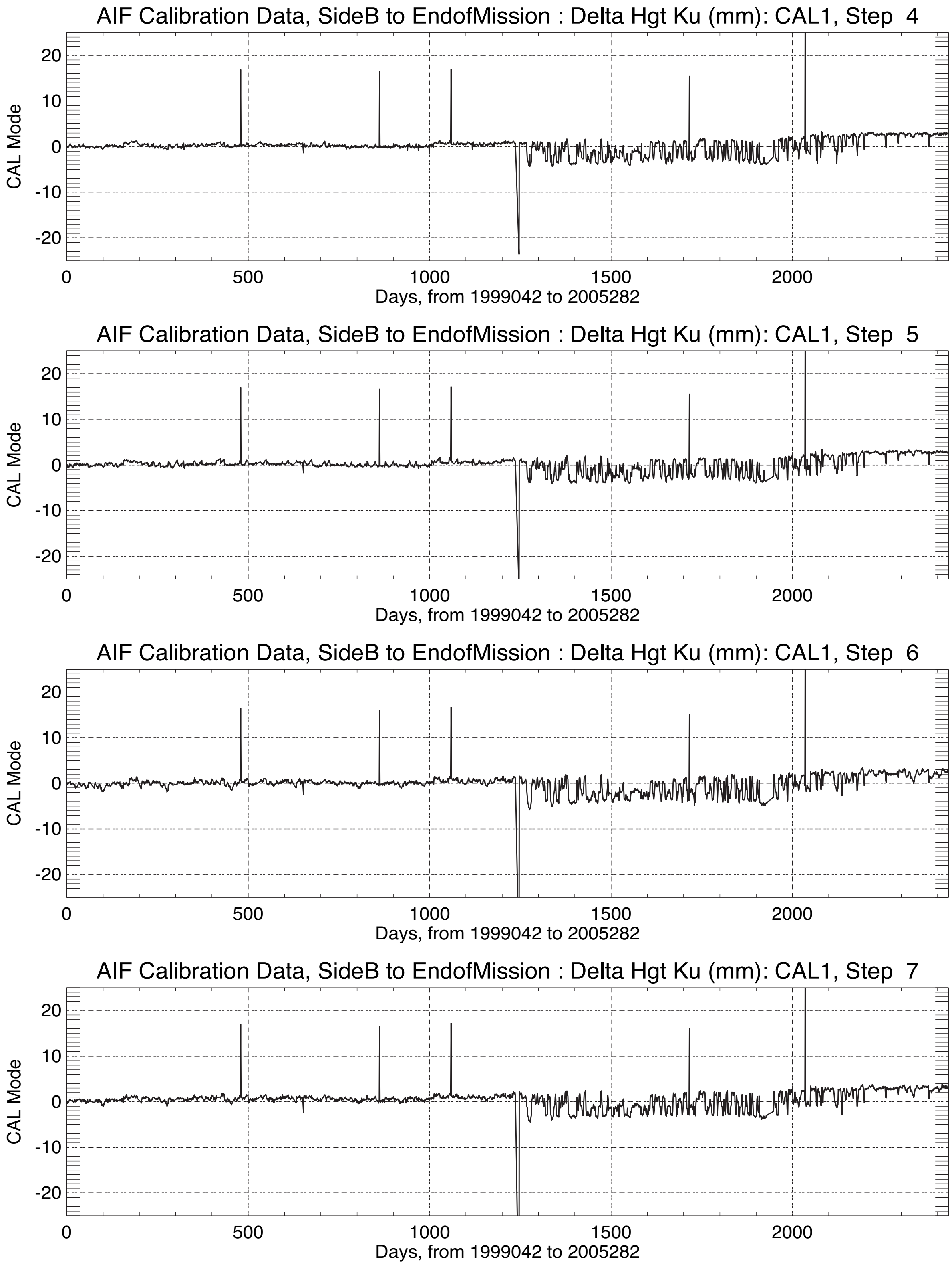

Figure 2-1 Ku-band Range CAL1 Results

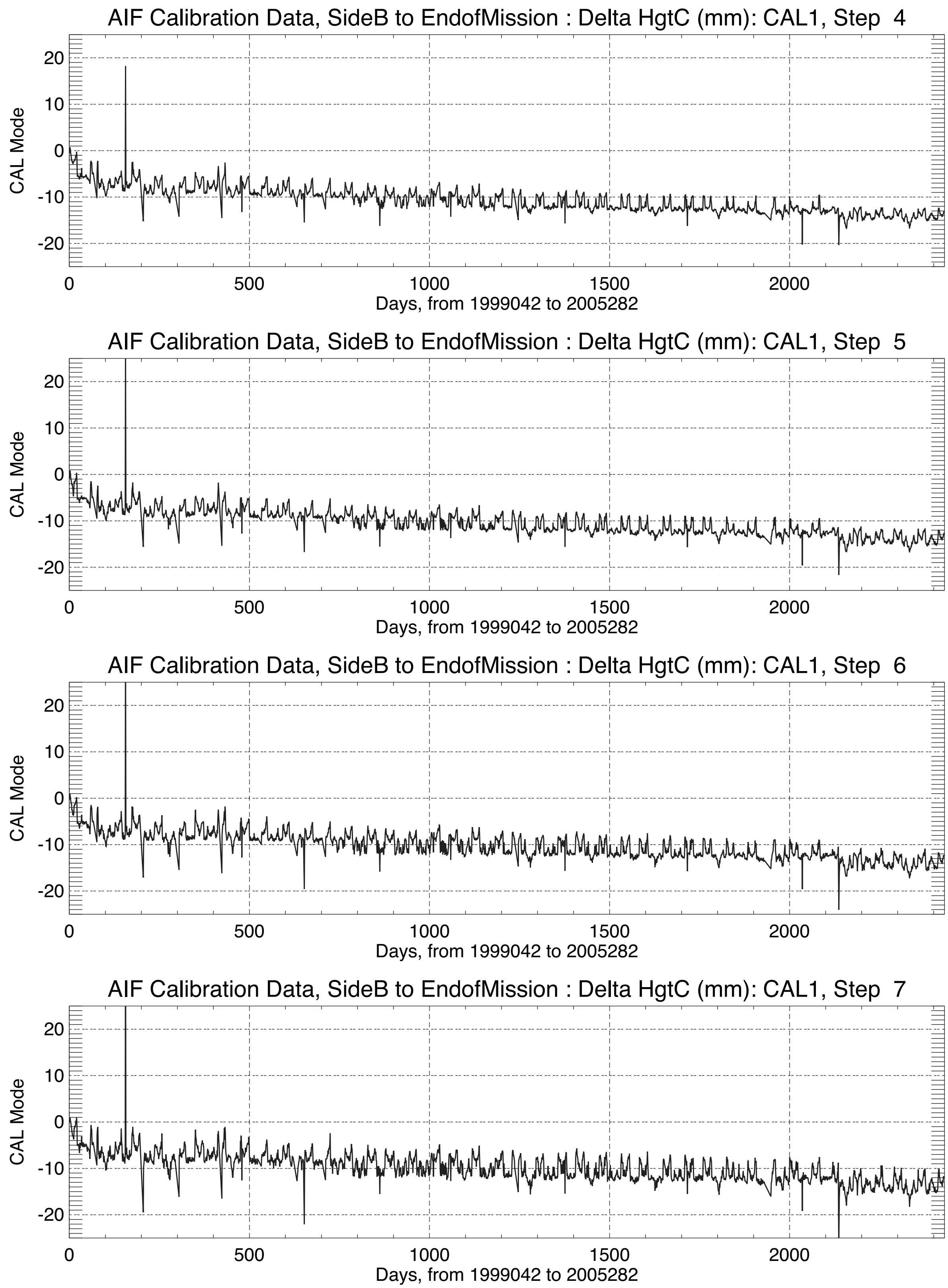

Figure 2-2 C-band Range CAL1 Results

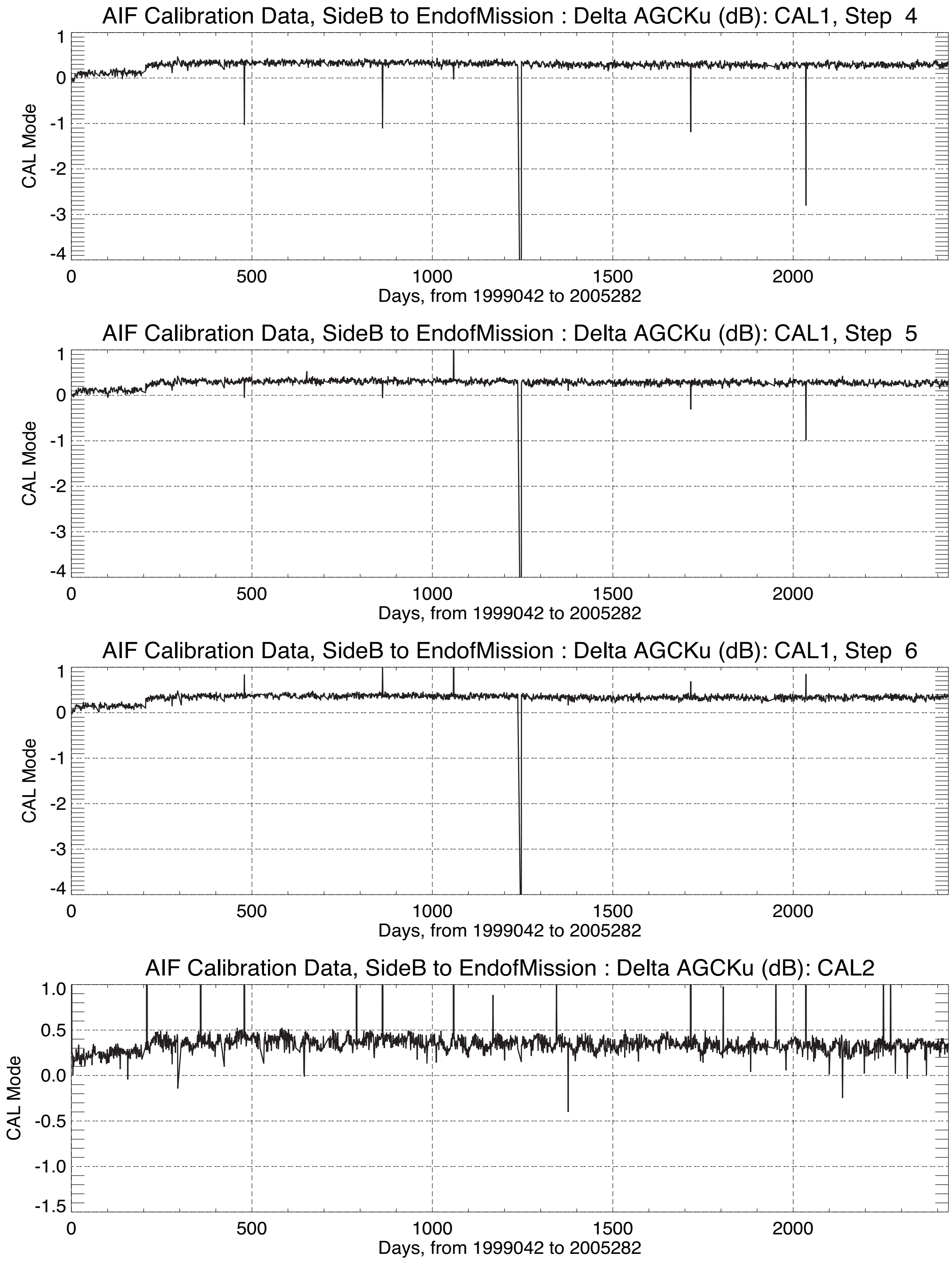

Figure 2-3 Ku-band AGC CAL1 and CAL2 Results

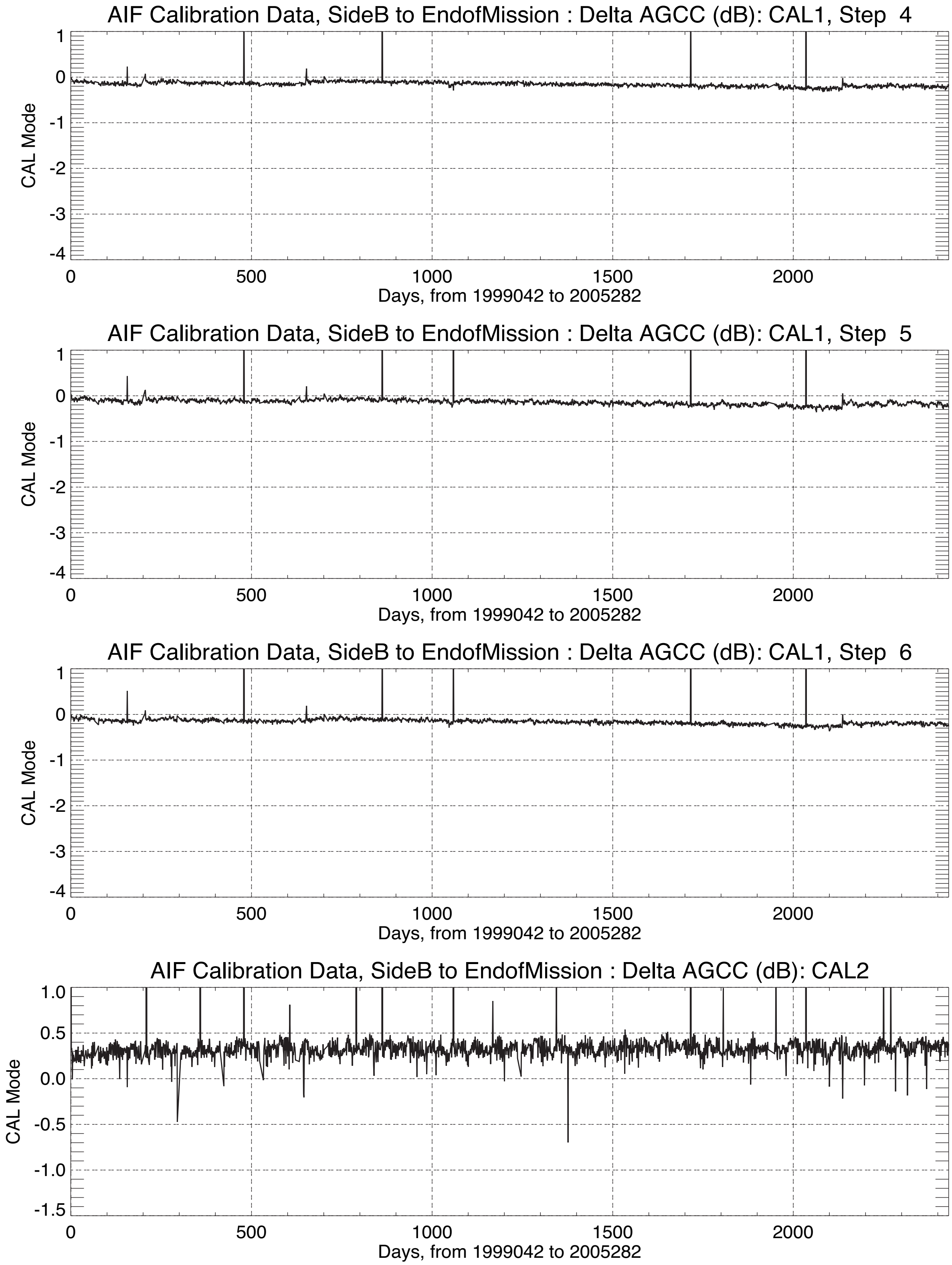

Figure 2-4 C-band AGC CAL1 and CAL2 Results

2.2 Side B Cycle Summaries

The data in the Side B cycle summary plots which follow were extracted from the Geophysical Data Record (GDR) database at WFF. The criteria for TOPEX GDR measurements to be accepted for the WFF database were: 1) the data are classified as Deep Water; 2) the data are in normal Track Mode; and 3) selected data quality flags are not set.

For each measurement type, the plots contain one averaged measurement per cycle. The cycle average value was itself the mean of one-minute along-track boxcar averages, after editing. Data were excluded from the averaging process whenever the one-minute-averaged off-nadir angle exceeded 0.12 degree or the averaged Ku-band sigma0 exceeded 16 dB or whenever the number of non-flagged frames within the one-minute interval was fewer than 45. These edit criteria primarily had to do with eliminating the effects of sigma0 blooms. As a result of this edit, approximately 15% of the database measurements were excluded from the averaging process. This tight editing was part of our effort to ensure that data from anomalous surfaces were excluded from the performance assessment process.

2.2.1 Sea Surface Height

The sea surface heights (ssh) contained in the GDR files are based on combined heights, where ssh is defined as the height of the sea surface above the reference ellipsoid after corrections for sensor and media effects. Cycle-average ssh are shown in Figure 2-5. It is not possible to discern range drifts at the millimeter level from these data, but seasonal variations of global sea level are observable. [There are 36.8 cycles per year.]

The period of orbit maneuvers that transferred TOPEX/Poseidon to a different orbit occurred between cycles 365 and 368 (2002-227 to 2002-259). Beginning with cycle 365, the ssh was more variable between cycles, and the mean ssh was approximately 0.5 m higher. We believe that the ~0.5 m ssh offset following the orbital change is most likely the result of the average mean sea surface values for the new groundtrack being slightly higher than the original groundtrack. We attribute the increased cycle-to-cycle variability to larger (on-average) cross-track gradients for the new groundtrack, and the gradients' effect on the sea surface heights as the groundtrack moves within the ± 1 km swath.

Beginning with cycle 443 and continuing to the end of this reporting period, there was an observed increase of ~2 m in ssh. We believe this was related to the data density since recorder usage had stopped. There were geographically-correlated gaps in the data that affected data distribution. This is described in last year's TOPEX Engineering Assessment Report, NASA TM-2005-212236, Volume 19.

2.2.2 Sigma0

The sigma0 cycle-averages are plotted in Figure 2-6 and Figure 2-7 for Ku-band and C-band, respectively. The GDR calibrated Ku-band sigma0 generally remained in a band between 10.95 and 11.35 dB, while the C-band was in a band between 14.40 and 14.80 dB.

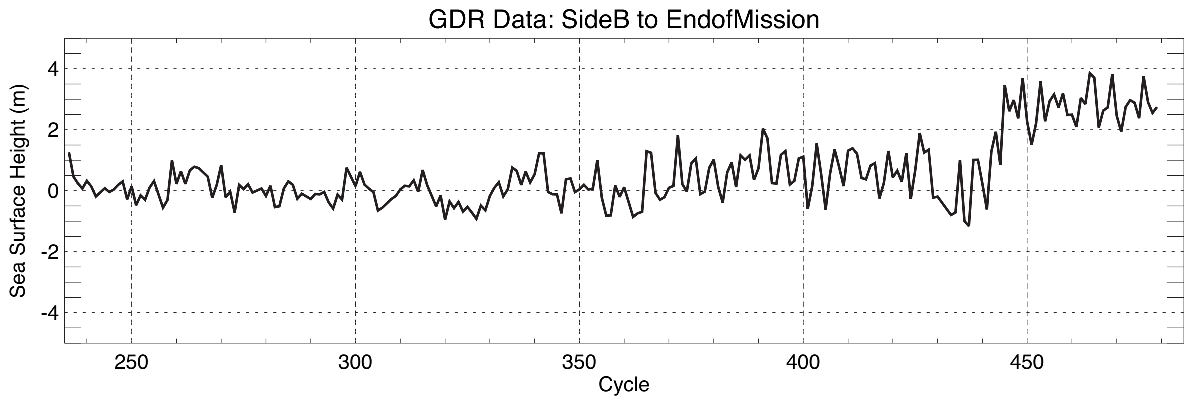

Figure 2-5 Cycle-Average Sea Surface Height in Meters

Sigma0 trends are discussed in more detail in Section 3.2.

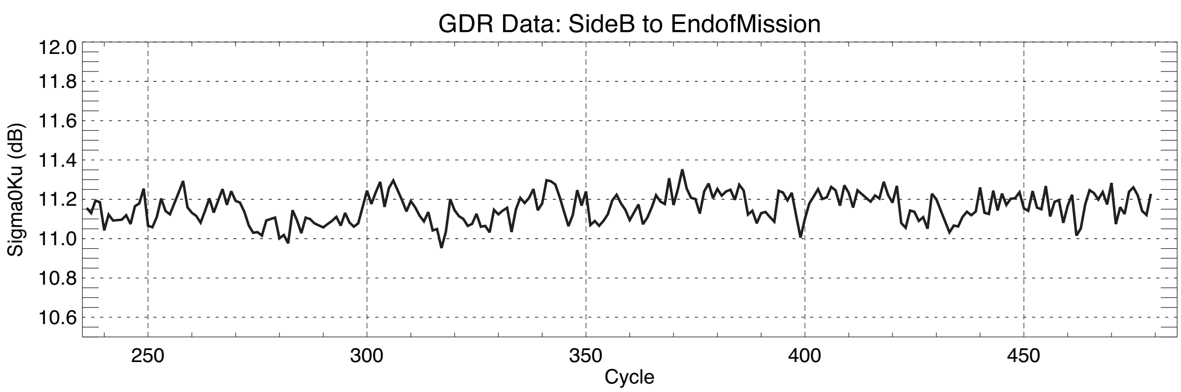

Figure 2-6 Cycle-Average Ku-band Sigma0 in dB

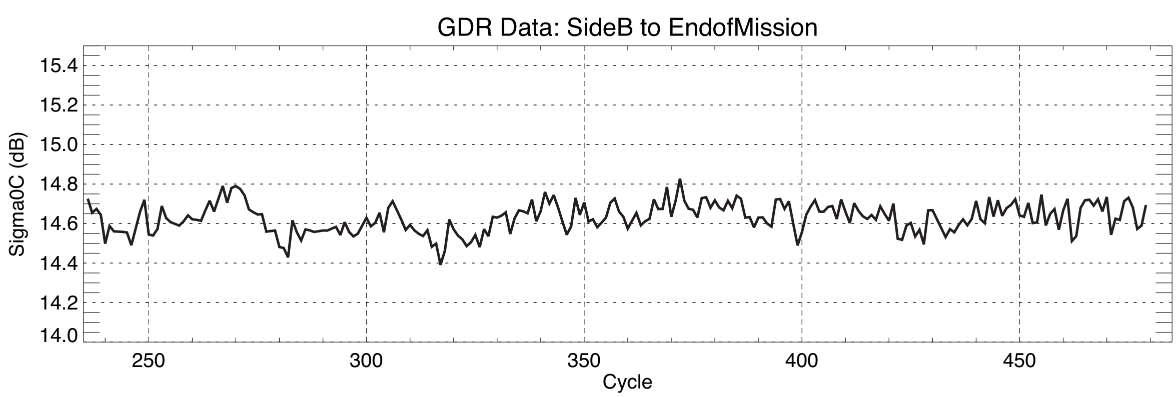

Figure 2-7 Cycle-Average C-band Sigma0 in dB

2.2.3 Significant Wave Height

Ku-band cycle-averages for significant wave height (SWH) are shown in Figure 2-8, and C-band cycle-averages for significant wave height (SWH) are shown in Figure 2-9. Seasonal trends in SWH are observable. Additional SWH performance assessments are presented later in Sections 4.2 and 5.2. Section 4.2 provides a monitor of Ku-band/C-band parameter differences, wherein Figure 4.2 "Cycle-Average SWH Delta in Meters" illustrates the difference of SWH C and SWH Ku. Section 5.2 provides a comparison of JASON and TOPEX, wherein Figure 5-2 "JASON/TOPEX Significant Wave Height Comparison" illustrates the comparison of the JASON/TOPEX SWH Ku and SWH C.

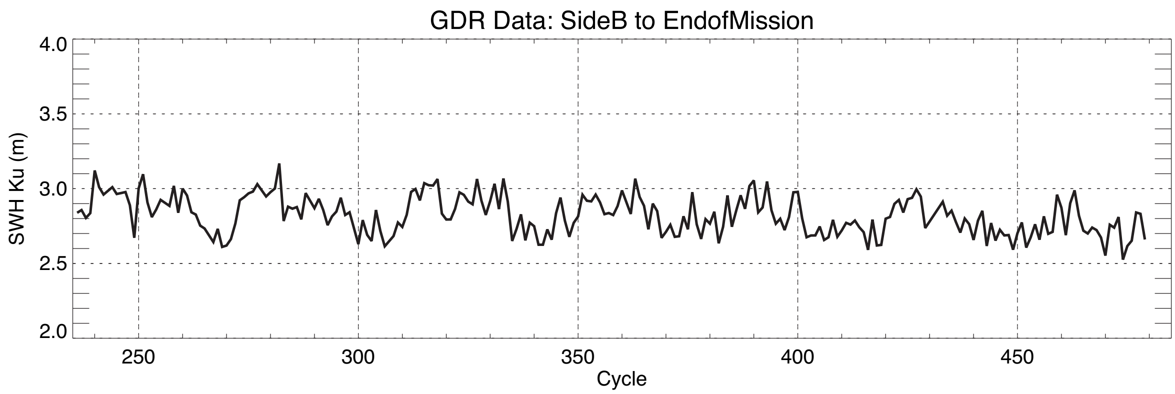

Figure 2-8 Cycle-Average Ku-band Significant Wave Height in Meters

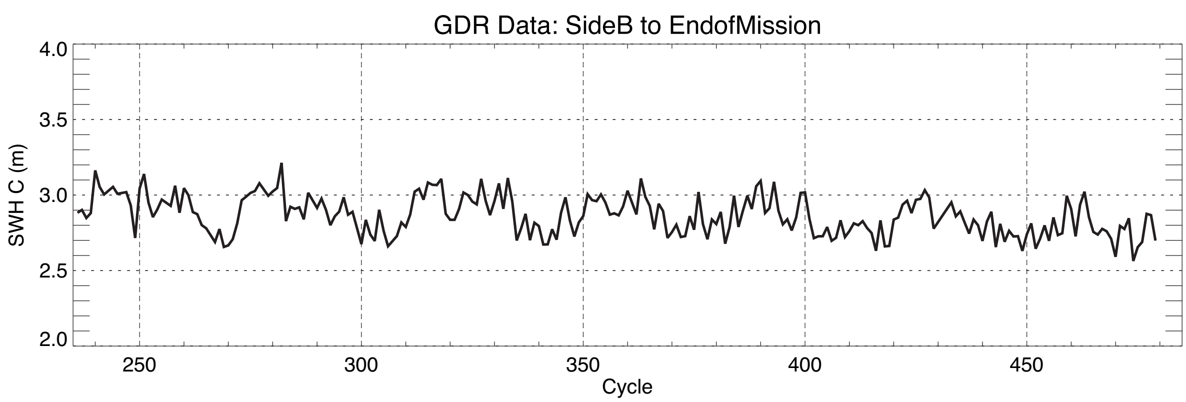

Figure 2-9 Cycle-Average C-band Significant Wave Height in Meters

Beginning around the time of cycle 430, and continuing to the end of this reporting period, there was an apparent small (~10 cm) decrease in cycle-average SWH for both Ku-band and C-band. We attribute this SWH decrease to gaps in TDRSS coverage, particularly in normally-high SWH areas of the southern Pacific Ocean.

2.2.4 Range RMS

The calculated Ku-band range rms values depicted in Figure 2-10 are based on the rms derivation described in Section 5.1.1 of the February 1994 Engineering Assessment Report. An expected correlation with SWH is apparent, as shown in Figure 2-11.

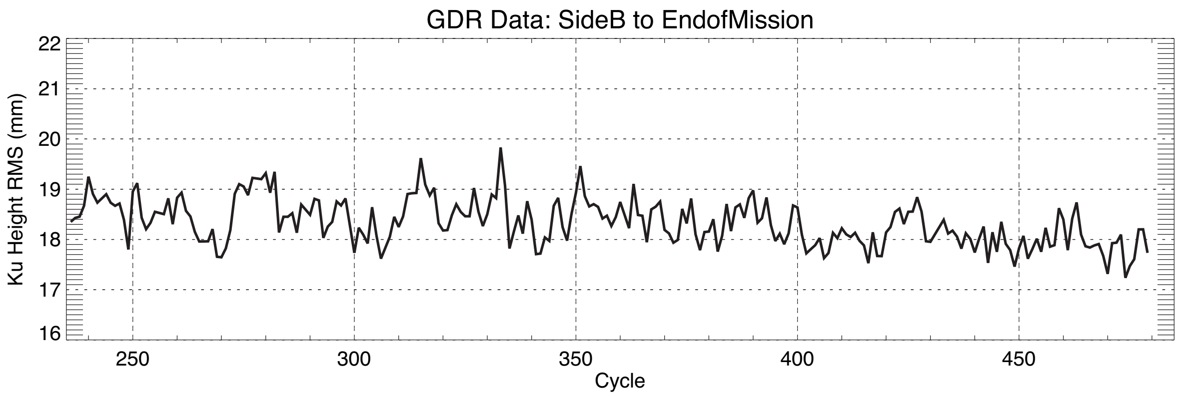

Figure 2-10 Cycle-Average Ku-band Range RMS in Millimeters

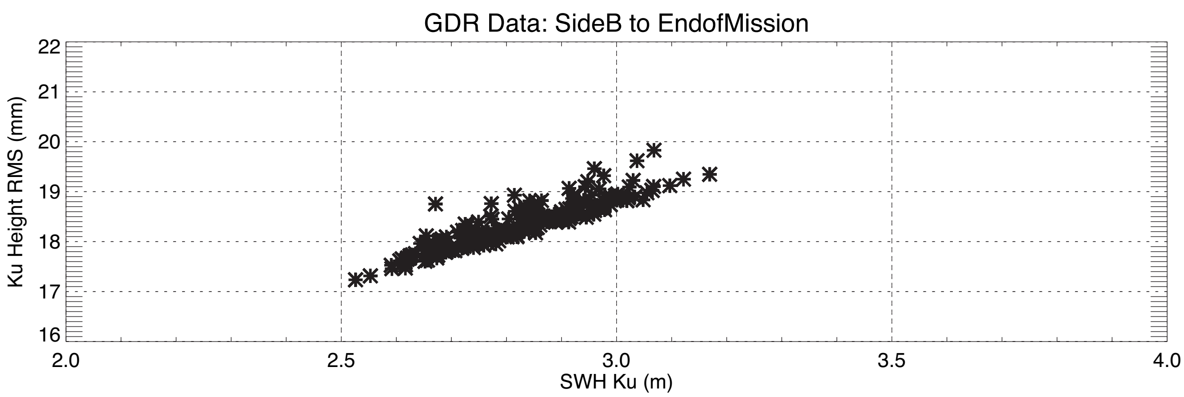

Figure 2-11 Ku-band Range RMS vs. SWH

2.2.5 Waveform Monitoring

Selected telemetered waveform gates during CAL2 and STANDBY modes were monitored daily, to discern waveform changes throughout the mission. CAL2 waveform sets were generally available twice per day, during calibrations. STANDBY waveforms were generally available four times per day, since the altimeter passed through STANDBY mode just prior to and immediately after each CALIBRATE mode. The relationship of telemetered waveform sample numbers to the onboard waveform-sample numbers is listed in Table 6.2.1 of the February 1994 Engineering Assessment Report.

For both Ku-band and C-band, the monitored waveform samples were as follows: CAL2 gates 23, 29, 48, and 93; and STANDBY gates 38, 39, 68, and 69. The Ku-band waveform sample history is shown in Figure 2-12 "Ku-band CAL2 Waveform Sample History" on page 2-13 and in Figure 2-13 "Ku-band STANDBY Waveform Sample History" on page 2-14 for CAL2 and STANDBY, respectively.

The C-band waveform history is depicted in Figure 2-14 "C-band CAL2 Waveform Sample History" on page 2-15 and in Figure 2-15 "C-band STANDBY Waveform Sample History" on page 2-16, respectively, for CAL2 and STANDBY.

The monitored Ku-band CAL2 waveform samples for Sides B in Figure 2-12 have each varied less than 1% throughout the mission, and exhibit little or no temperature dependence.

The Ku-band STANDBY waveform samples in Figure 2-13, in contrast, had a slight inverse dependence on temperature (launch-to-date temperatures are shown in Figure 2-16 on the same horizontal time scale as the waveform samples). From the time of Side B turn-on, each of the four sampled gates quickly increased between 5% and 20%, and then remained fairly steady. Gate 69 continued to decrease slightly.

The Side B C-band CAL2 waveforms samples, shown in Figure 2-14, are similar to the Ku-band CAL2 waveforms in that they vary less than about 1%, and exhibit no apparent temperature dependence.

The C-band STANDBY waveform samples, shown in Figure 2-15, are similar to their counterpart Ku-band STANDBY waveforms in that Gates 38, 39, 68, and 69 had an inverse dependence on temperature, and each experienced increases shortly after turn-on. Gate 69 continued its decrease, accompanied by an increase in variability commencing around day 1300.

In Figure 2-14, CAL2, Gate 93, there are waveform spikes at the labeled days of 210, 359, 480, 800, 861, 1073, and 1722. The reasons for these spikes are posted in the "Side B Key Events", in Appendix C, Table C-2. The causes were: Day 210 (1999-252), Digital Filter Bank Calibration; Day 359 (2000-036), Digital Filter Bank Calibration; Day 480 (2000-157), Improper SEU recovery from a Digital Filter Bank Interface Lockup; Day 800 (2001-112), Improper SEU recovery; Day 861 (2001-173), Improper SEU recovery; Day 1073 (2002-020), Failed Digital Filter Bank Leakage Test; Day 1722 (2003-303), Improper SEU recovery.

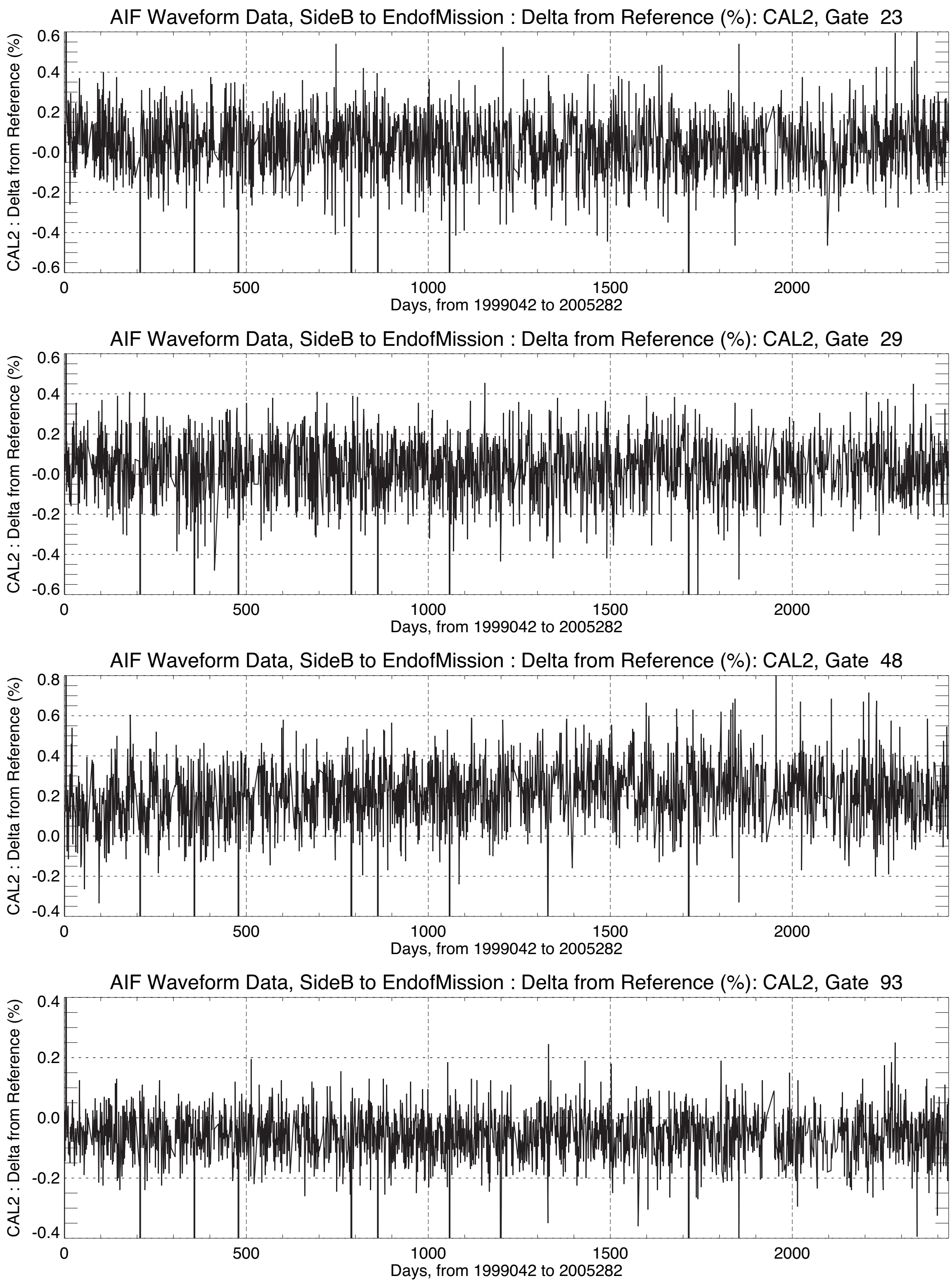

Figure 2-12 Ku-band CAL2 Waveform Sample History

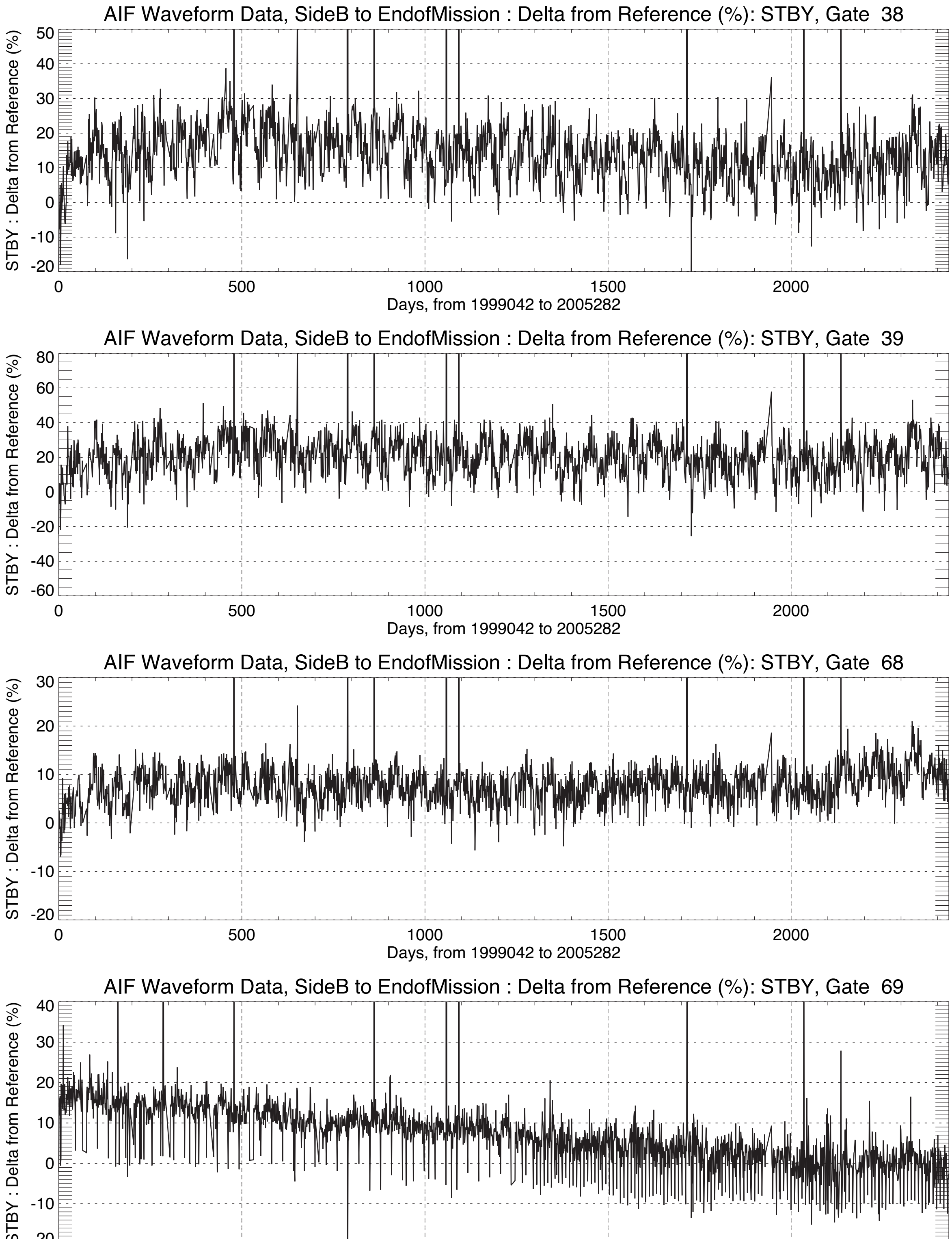

Figure 2-13 Ku-band STANDBY Waveform Sample History

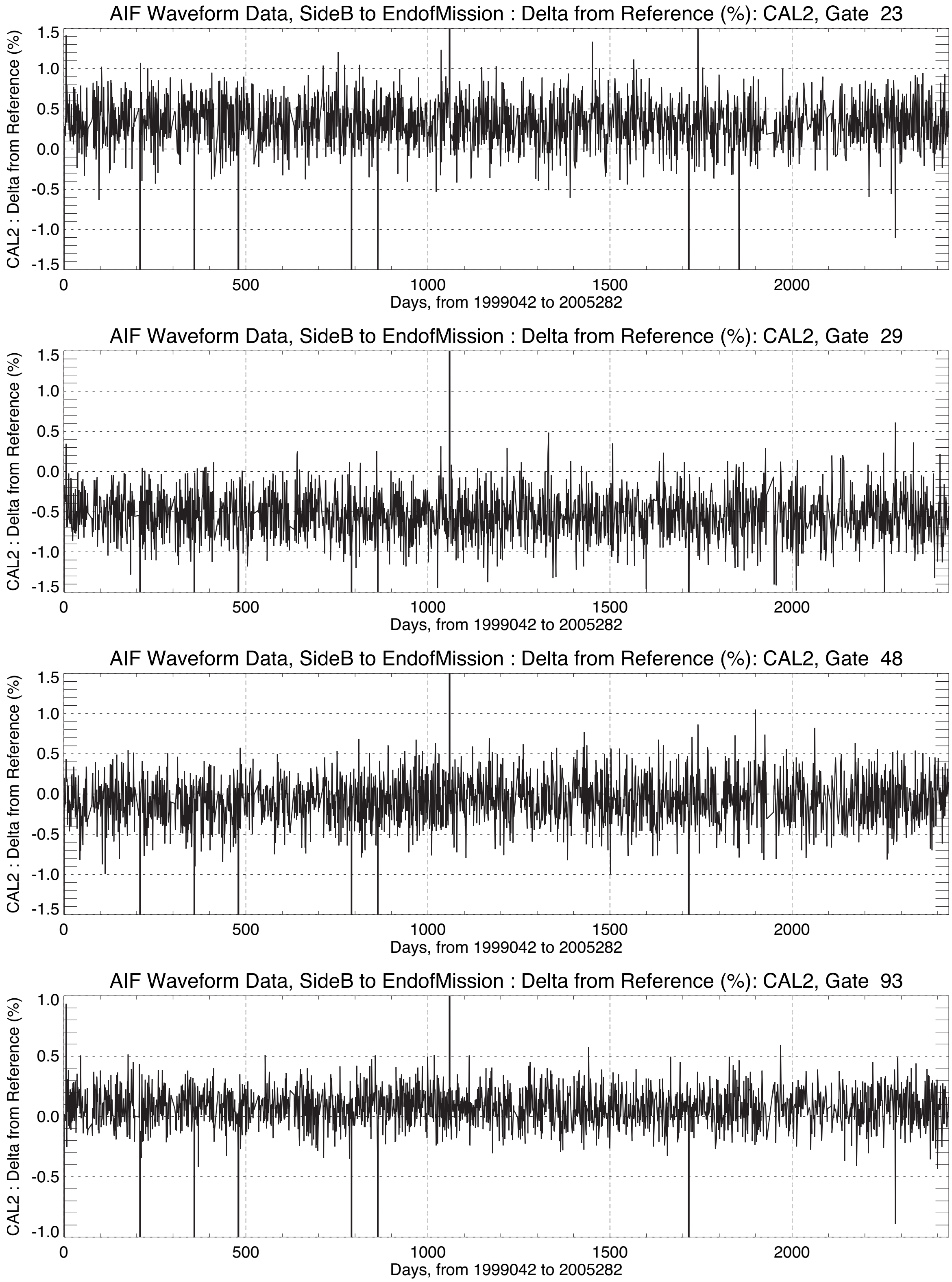

Figure 2-14 C-band CAL2 Waveform Sample History

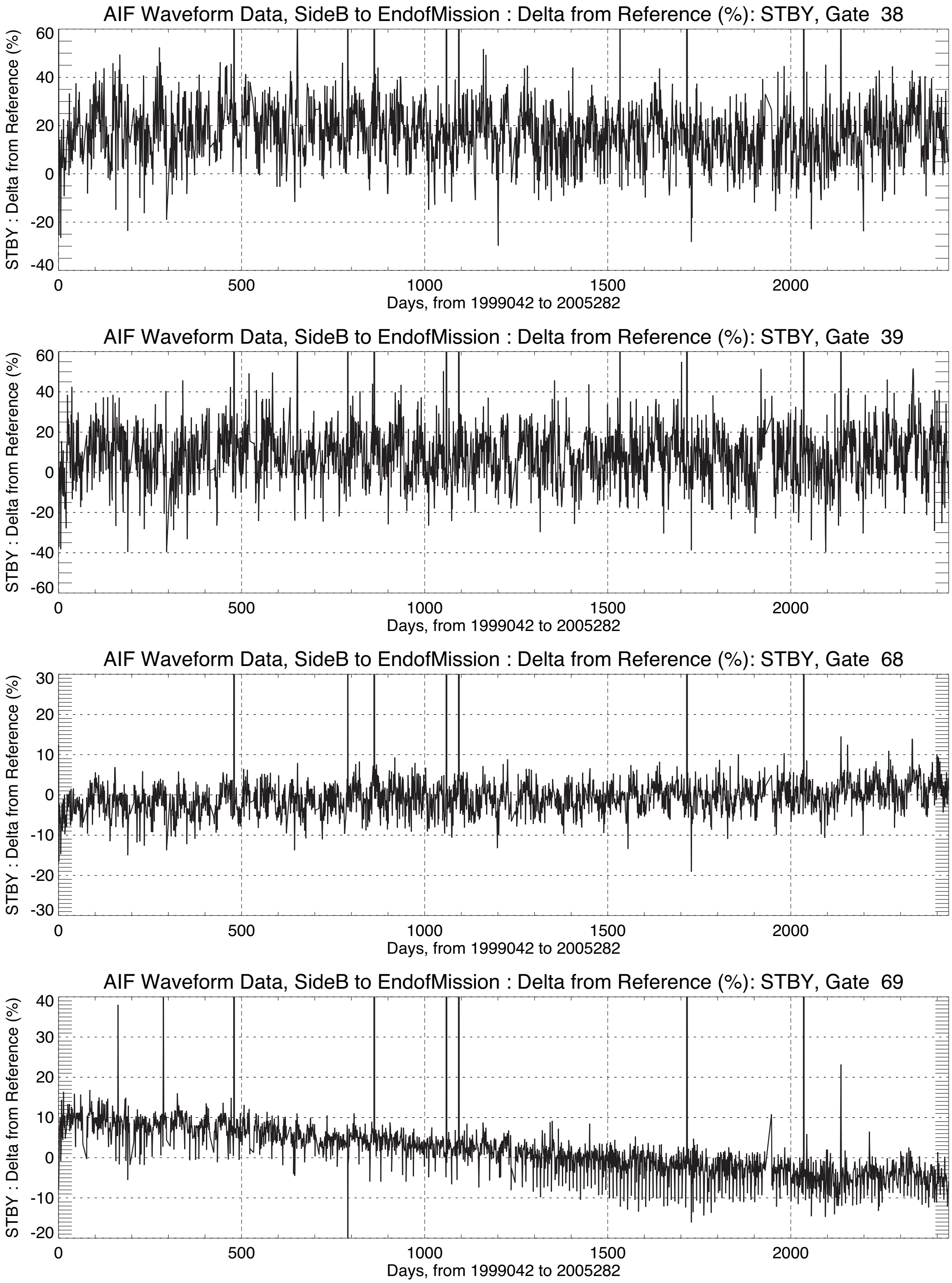

Figure 2-15 C-band STANDBY Waveform Sample History

2.2.6 Engineering Monitors

Altimeter temperatures, voltages, powers and currents were monitored for the life of the mission. The system remained very stable, with no significant change since Side B turn-on. The engineering monitor plots presented in this section contain data based on 24-hour time periods, showing the average, the minimum, and the maximum values during each 24-hour period.

2.2.6.1 Temperatures

The Side B temperatures of all 26 internal thermistors continued to be within the design temperature range and, except for the DCG Gate Array, were within the ranges experienced during the pre-launch Hot and Cold Balance Tests. The minimum/maximum values for all the other thermistors during TRACK mode remained within the bounds listed in Table 7.1 of the TOPEX Mission Engineering Assessment Report, February 1994, and they compose plots 2 through 27 in Figure 2-16 "Engineering Monitor Histories" on page 2-18.

The thermistor plots for 2005 are shown in greater detail in Appendix D. As noted in previous years' assessment reports, the DCG Gate Array temperature is about 30 degrees higher than that experienced during pre-launch testing. The temperature has exhibited a slow rise from Side B turn-on of about 0.5 degree per year for about 1300 days. The stabilization of the temperature level could be an indication that the debonding of the heat sink stabilized. The lifetime thermal analysis of a similar DCG Gate Array unit indicated there was no great concern and the six years of performance confirms this analysis.

Although not used during our routine monitoring, several of the altimeter-related baseplate temperature monitors serviced by Remote Interface Unit (RIU) 6B became uncalibrated on day 17 of 1995. The affected temperature monitors are listed in Section 2.2.6.1 of the 1996 Engineering Assessment Report. An abrupt change in the values occurred on that date, apparently due to a change in the current which was applied to the thermistor circuits.

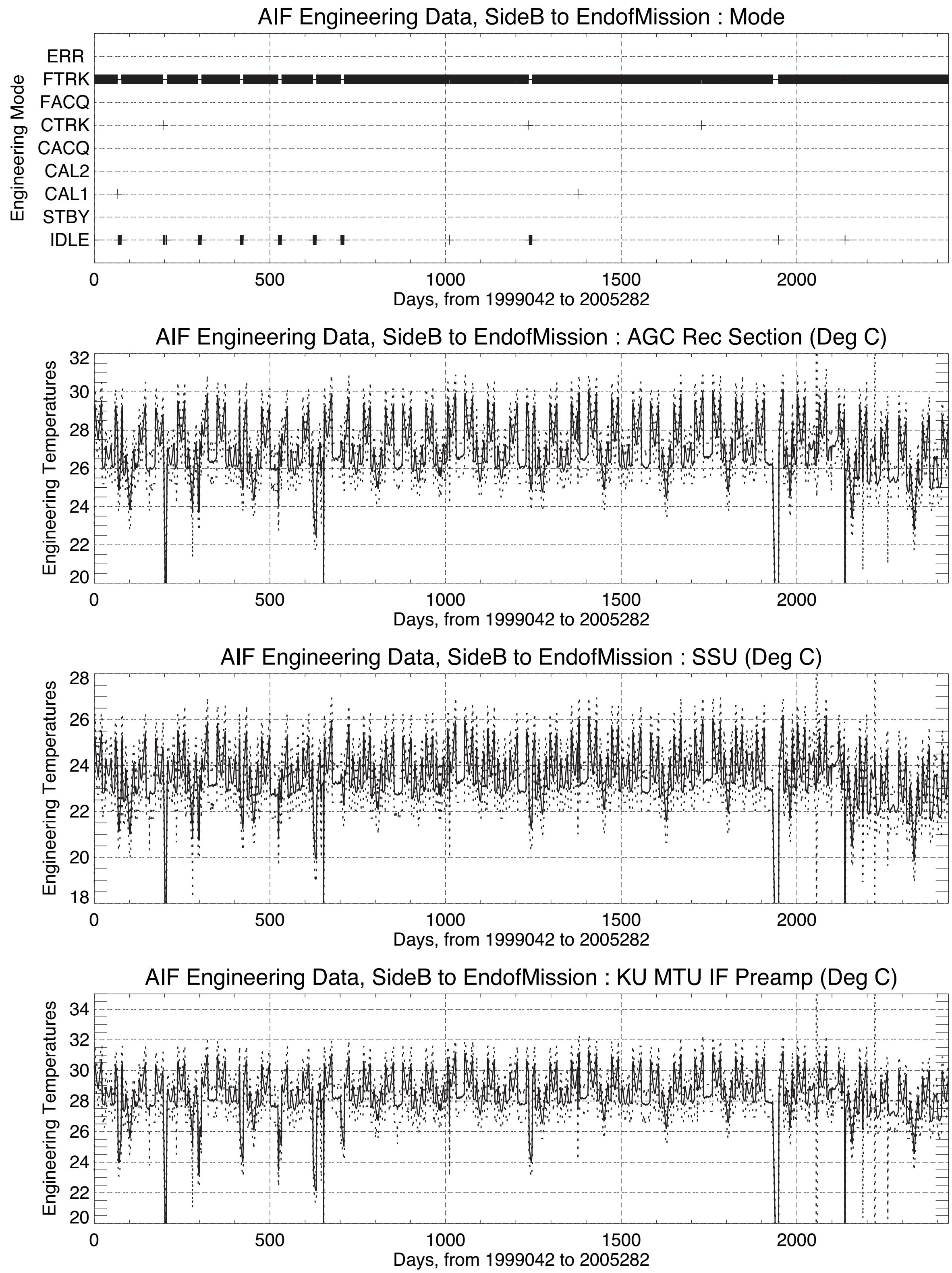

Figure 2-16 Engineering Monitor Histories

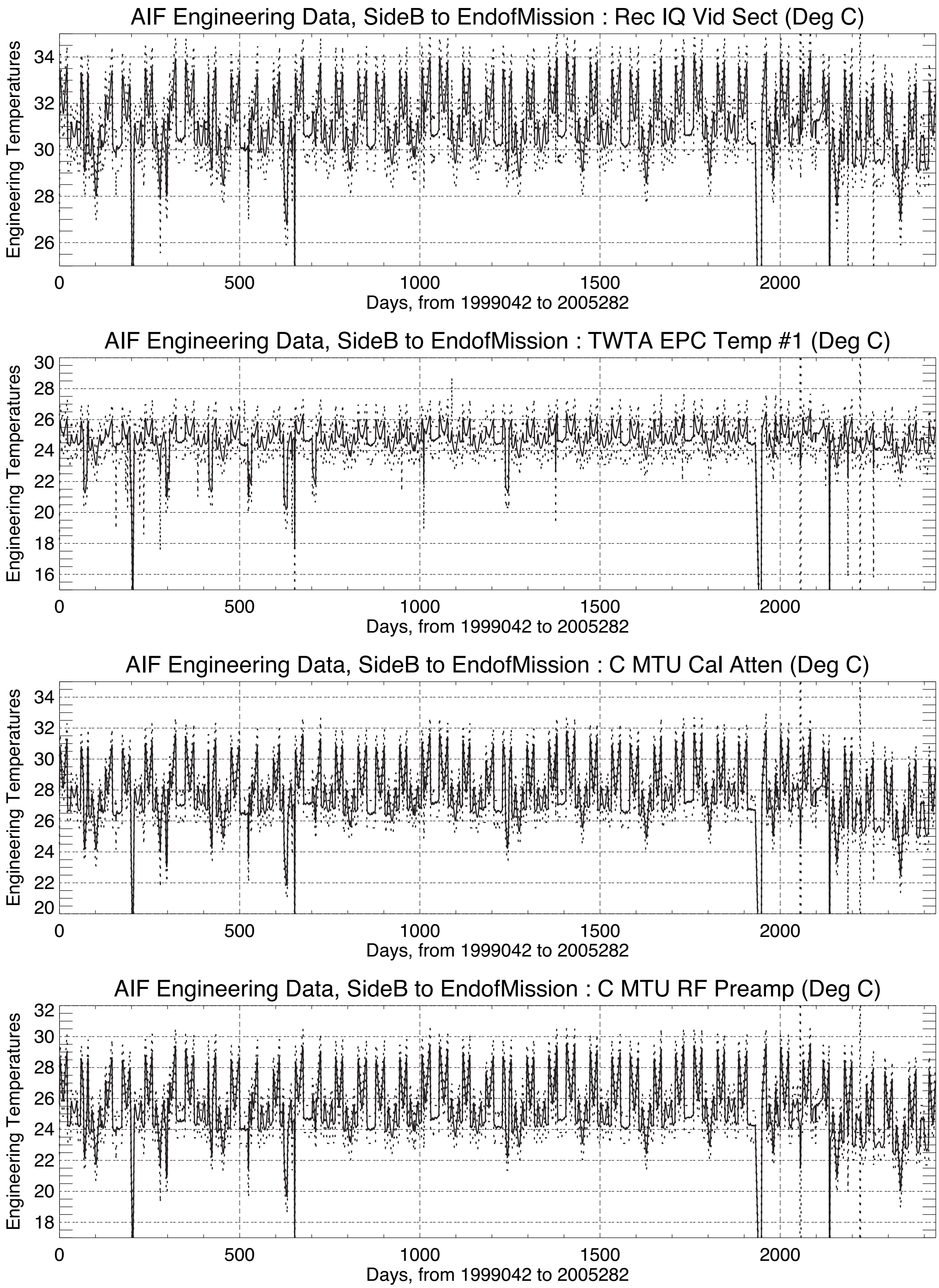

Figure 2-16 Engineering Monitor Histories (Continued)

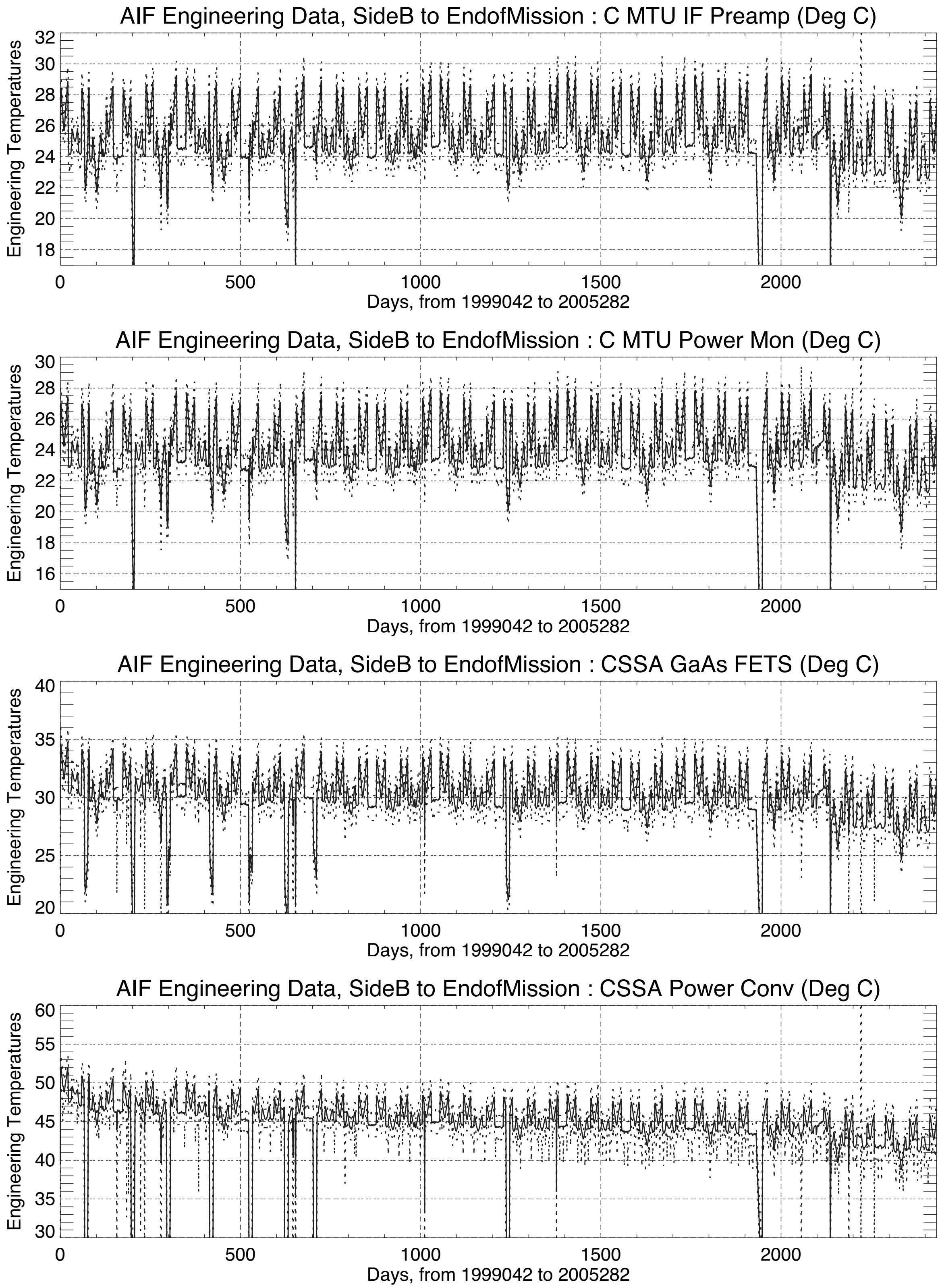

Figure 2-16 Engineering Monitor Histories (Continued)

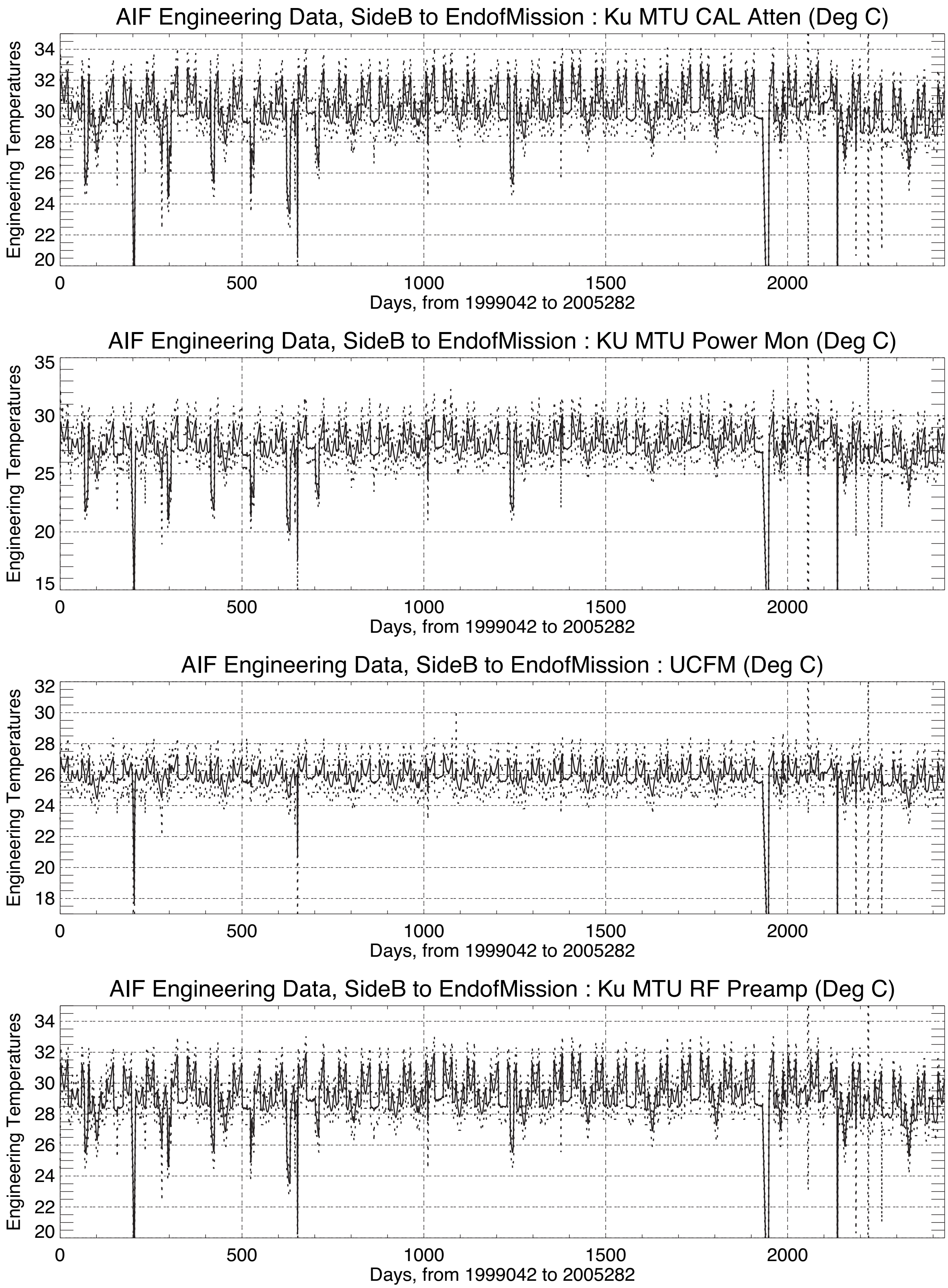

Figure 2-16 Engineering Monitor Histories (Continued)

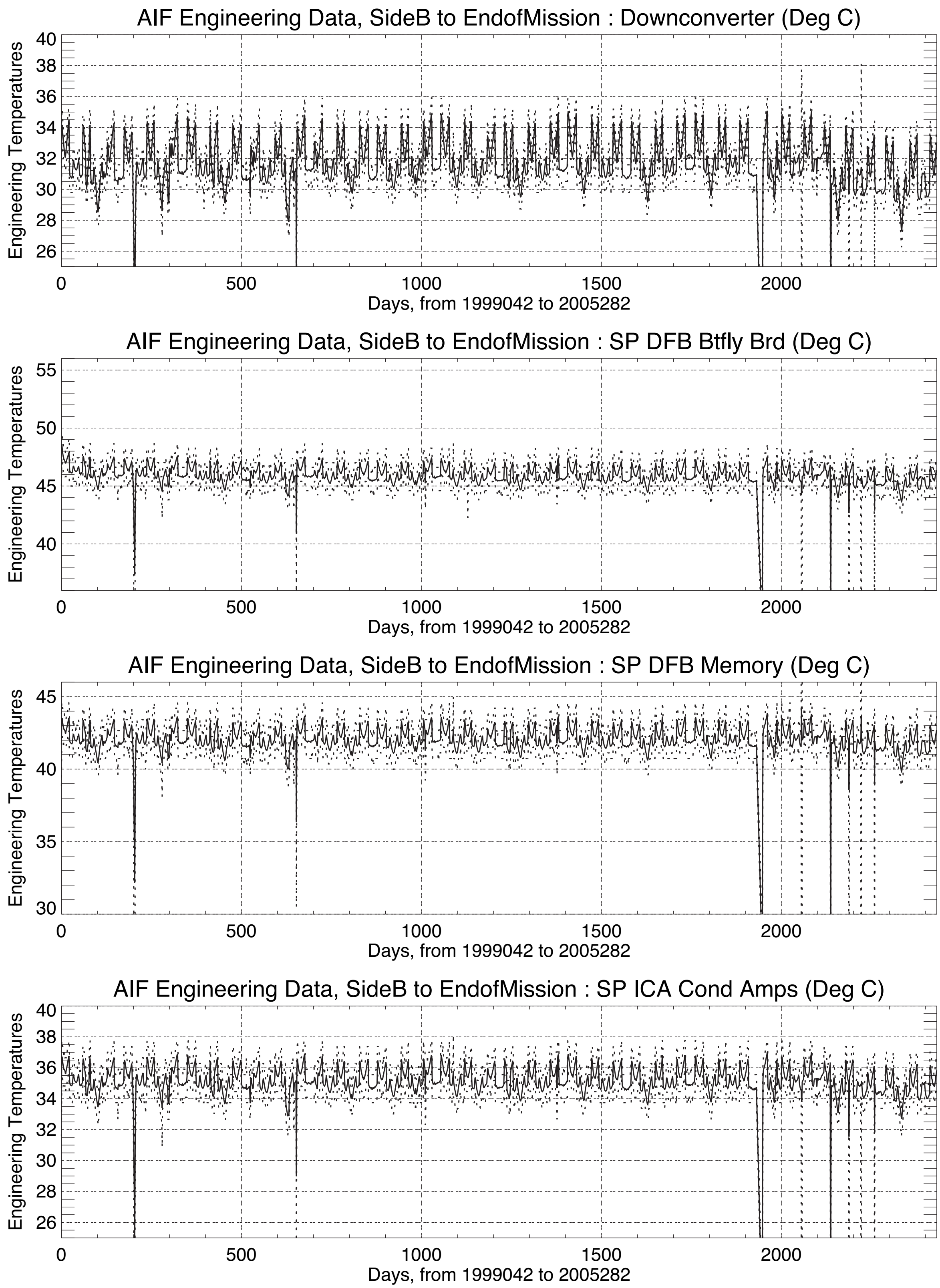

Figure 2-16 Engineering Monitor Histories (Continued)

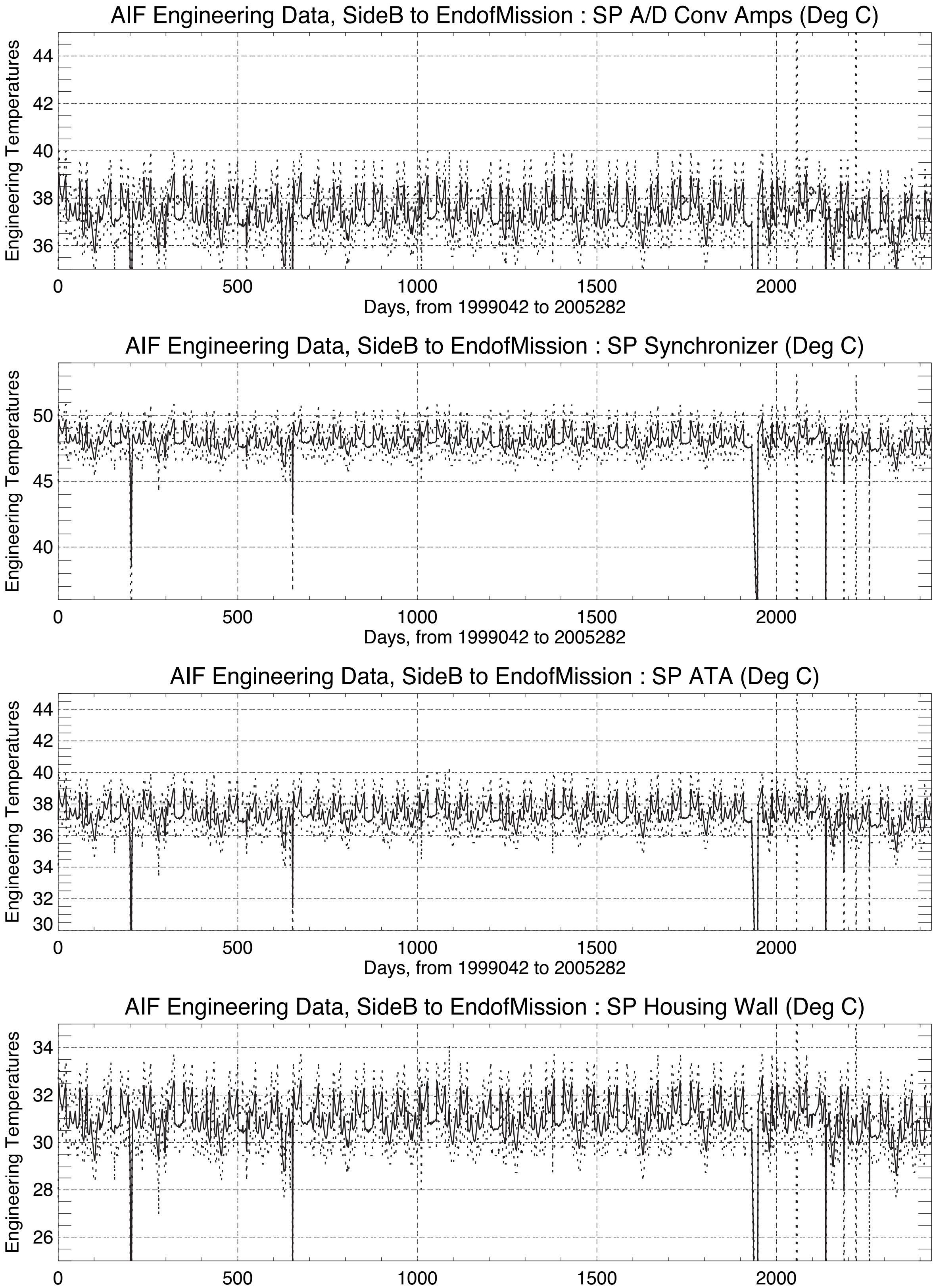

Figure 2-16 Engineering Monitor Histories (Continued)

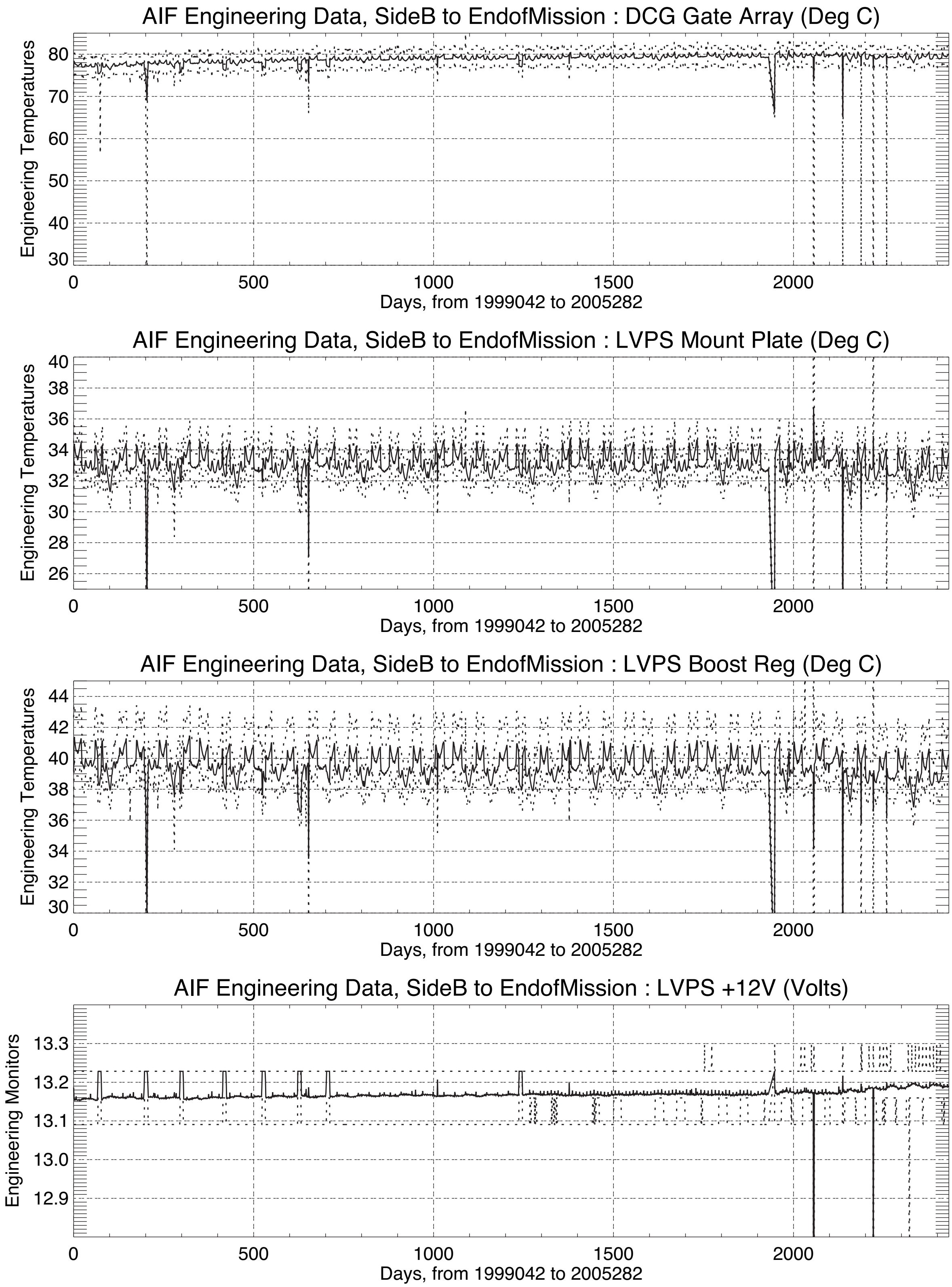

Figure 2-16 Engineering Monitor Histories (Continued)

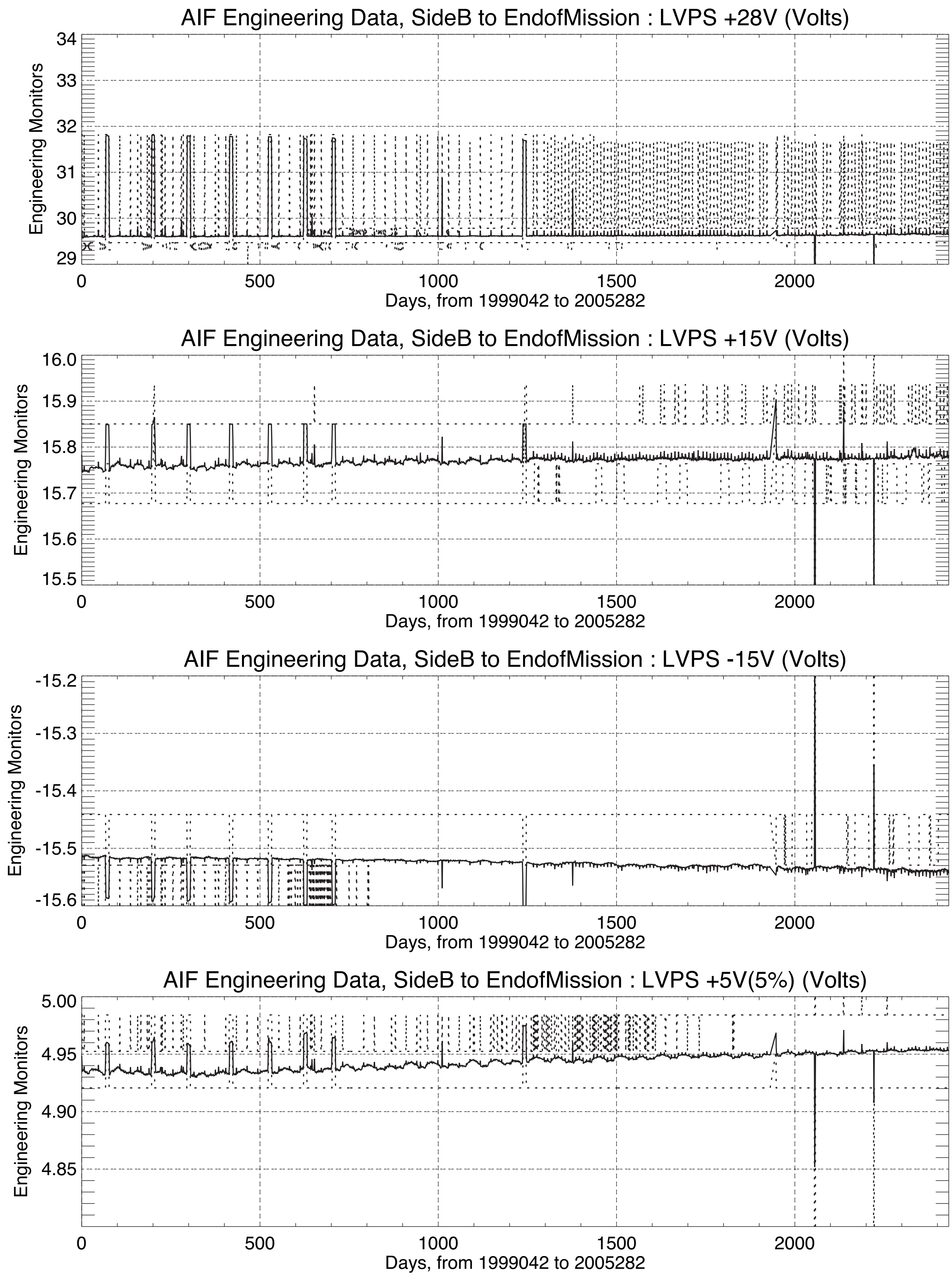

Figure 2-16 Engineering Monitor Histories (Continued)

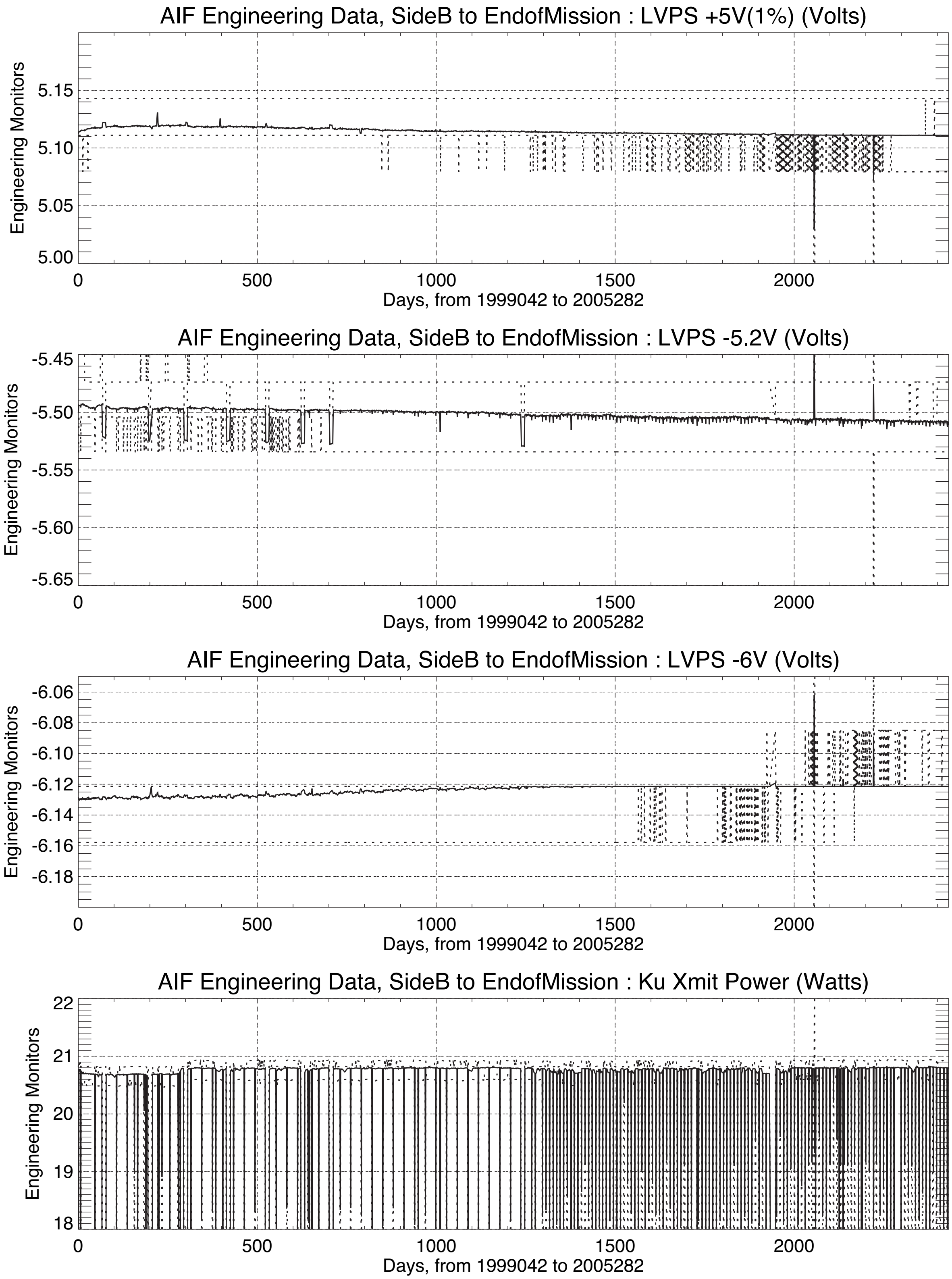

Figure 2-16 Engineering Monitor Histories (Continued)

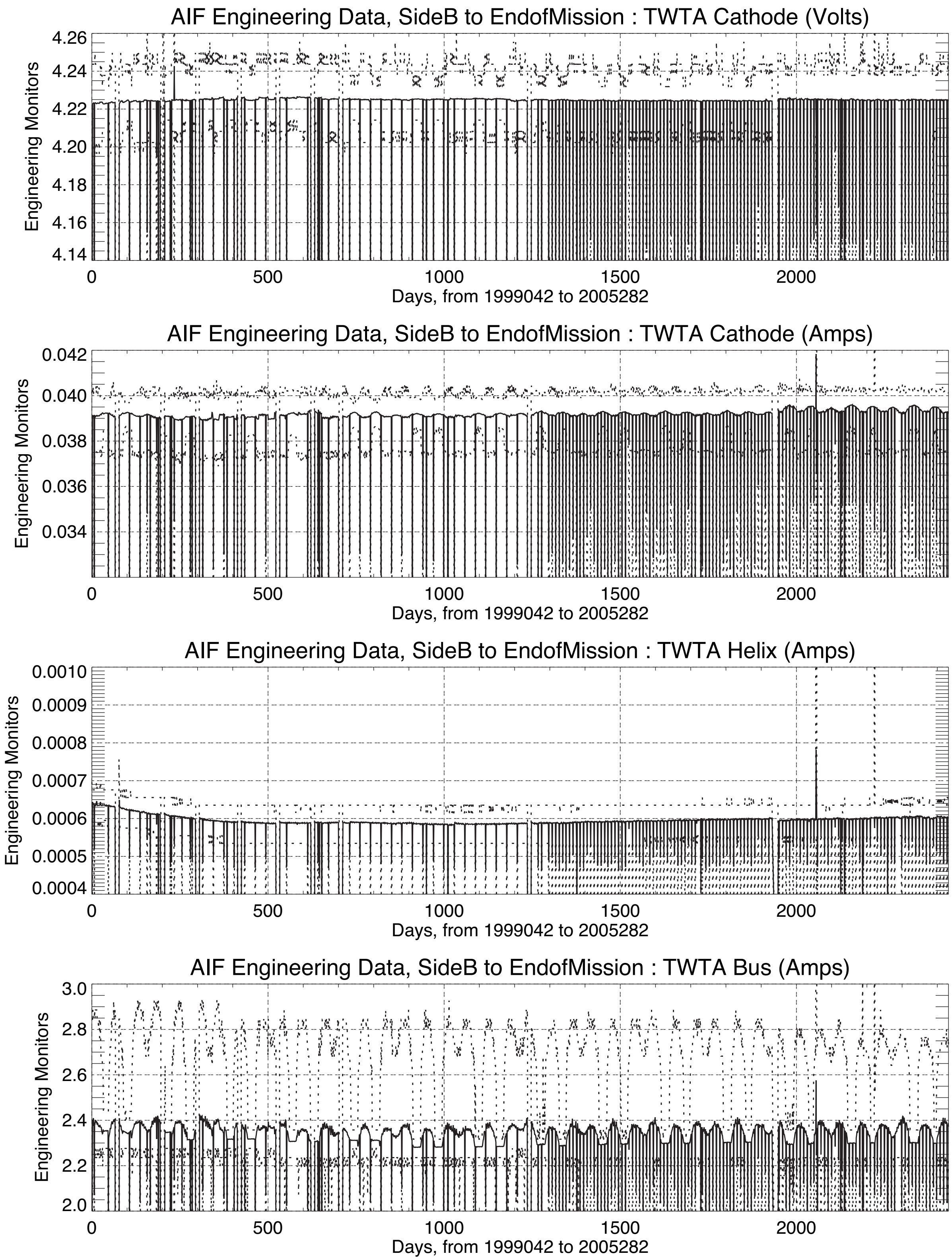

Figure 2-16 Engineering Monitor Histories (Continued)

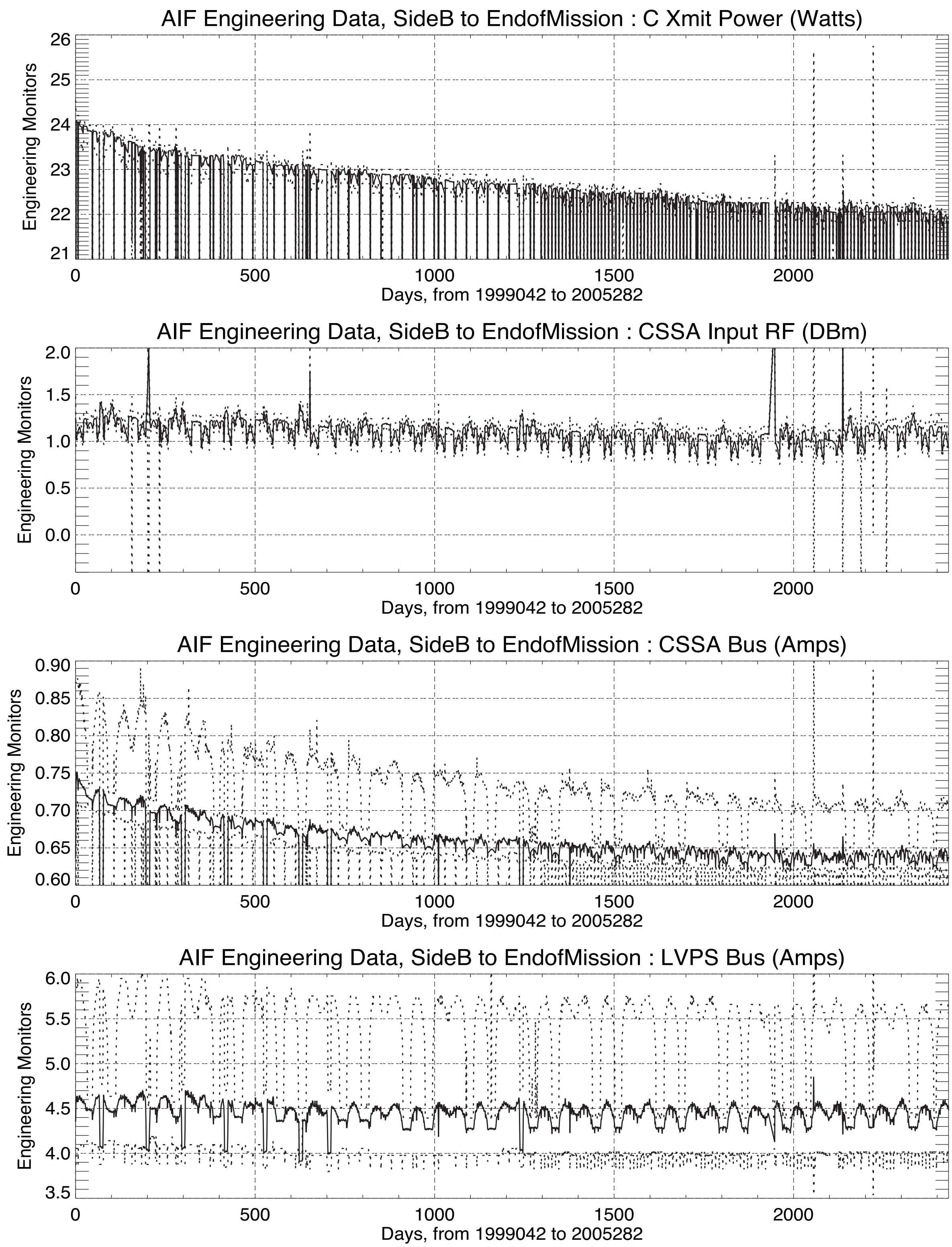

Figure 2-16 Engineering Monitor Histories (Continued)

2.2.6.2 Voltages, Powers and Currents

The altimeter's 17 monitors for voltages, powers and currents remained at consistent levels, with little deviations. Their Side B to end-of-mission histories are also shown in Figure 2-16 "Engineering Monitor Histories", and they compose plots 28 through 44 on page 2-18. The 17 monitors are shown in greater detail for 2005 in Appendix D.

The eight voltages [LVPS +12V, LVPS +28V, LVPS +15V, LVPS -15V, LVPS +5V(5%), LVPS +5V(1%), LVPS -5.2V and LVPS -6V] have changed very little since Side B turn-on.

The following changes since turn-on of Side B are noted:

- The TWA Helix current had decreased about 0.05 milliamperes by the end of 2003, but had a slow increase of about 0.01 milliamperes by the end of the mission.
- The C-band Transmit Power had decreased approximately 2 watts since Side B turn-on.
- There has been a gradual decrease in the CSSA Bus current level; the level has decreased 0.11 amp since Side B turn-on to the end-of-mission. This is consistent with the C-band transmit decrease.
- Minor changes occurred in a number of C-band engineering monitors after the safehold of day 2136 (2004-353). This is reflected in about a degree lower in C-band thermistor monitors which in turn produced an average of 0.128 dB increase in CSSA input.

2.2.7 Single Event Upsets

There have been a total of 385 Single Event Upsets (SEUs) from the initial turn-on of Side B to the end of the mission, an average of one SEU per 6.3 days. The vast majority of the SEUs occurred in the South Atlantic Anomaly, as shown in Figure 2-17 "Locations of SEU Occurrences" on page 2-30. It has been noted that there has been an increasing number of SEUs occurring outside the South Atlantic Anomaly, in the South Pacific area. The dots in Figure 2-17 denote the locations of SEU occurrences that automatically recovered, while the diamonds indicate that the SEU required manual commanding to recover.

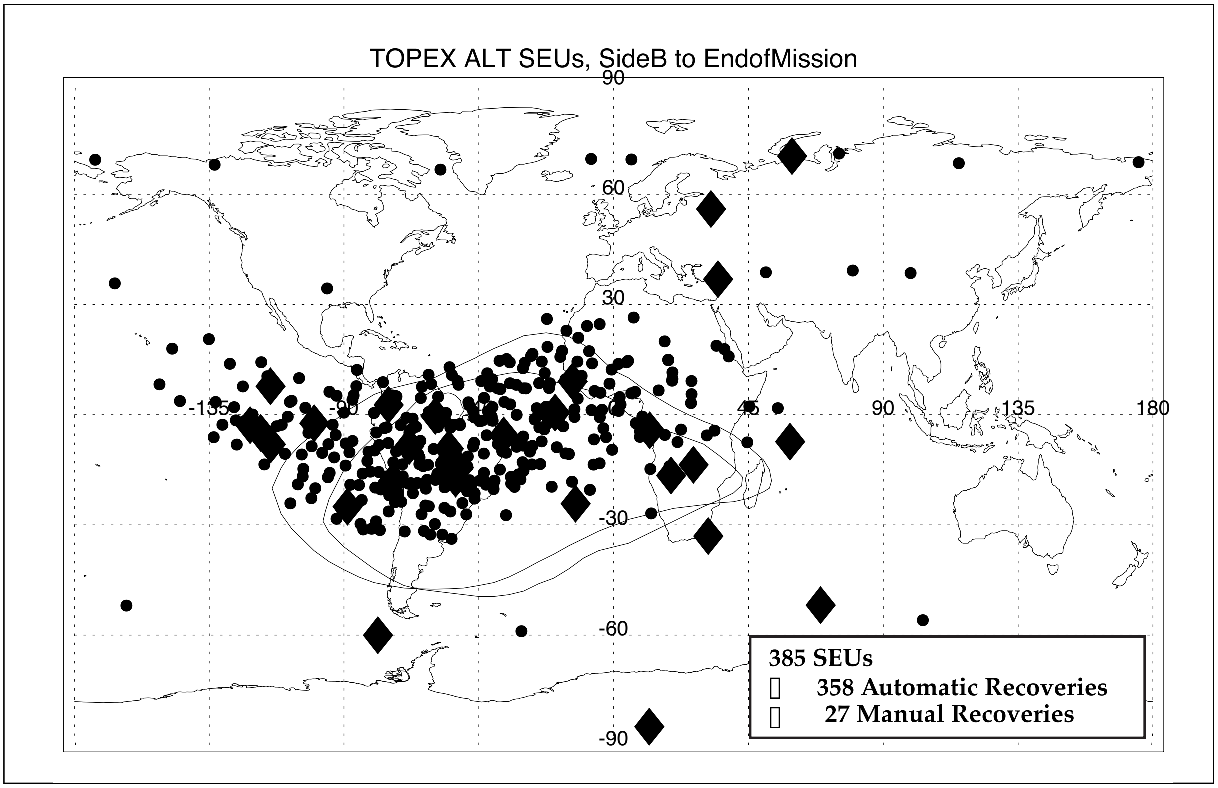

Figure 2-17 Locations of SEU Occurrences

The altimeter processor automatically recovered from 358 of the SEUs; the other 27 required manual (ground-based command) resets. Each of the automatic resets, generally, resulted in the loss of only a few seconds of data.

As of the end-of-mission, there have been a total of 40 anomalous Side B resets (the 27 manual resets plus 13 additional abnormal automatic resets). Table 2-1 lists the dates of these 40 SEUs, along with the type of on-board reset and the duration of the effect on the data.

Regarding the two abnormal automatic resets in 2005:

- Day 2005-078 - The waveforms were not updating and range sweep patch detected range wraparound. The altimeter reset itself.

- Day 2005-176 - The waveforms were not updating and a range sweep patch detected range wraparound. The altimeter reset itself.
- Day 2005-255 - The TOPEX experienced an SEU at 4:44 UTC that was automatically recovered. However it did leave some non refreshed memory locations corrupted. One of these was the storage location for the last command received that was loaded into the telemetry. The resulting bit pattern in the engineering telemetry for the first byte of the last command indicated a command error condition. This led to the JPL operations team seeing “ACME” alarms on the first byte of the last command words. The operator sent the SA28 Command File at 7:06 UTC which manually reset the altimeter computer and this changed the last command to be the ground reset command without the error bit set. It appeared the altimeter was working normally between the 4:44 reset and the manual reset at 7:06. We believe that this was very similar to the automatic recoveries that sometime leave the science spare words corrupted and require a manual operation to restore.

Table 2-1 Anomalous Single Event Upsets

Year	Day	Duration (Hr)	Reset Type	Type SEU
Side B				
1999	071	0.7	Manual	DFB Interface Lockup
1999	198	5.6	Manual	C MTU Xmit
1999	223	1.6	Manual	Memory Corrupted
1999	246	13.0	Manual	Eng Interface Lockup
1999	276	3.1	Manual	Ku MTU Xmit
1999	280	0.1	Automatic	No WF Update/Rng Sweep
2000	056	0.1	Automatic	Eng Spare Word Corrupted
2000	067	5.8	Manual	Sci Telemetry Lockup
2000	157	1.9	Manual	DFB Interface Lockup
2000	227	1.4	Manual	Sci Telemetry Lockup
2000	275	1.1	Manual	DFB Interface Lockup
2001	070	0.1	Automatic	No WF Update
2001	079	1.3	Manual	Sci Telemetry Lockup
2001	112	1.3	Manual	DFB Interface Lockup
2001	166	0.1	Automatic	No WF Update/Rng Sweep
2001	173	3.2	Manual	DFB Interface Lockup
2001	205	3.0	Manual	DFB Interface Lockup

Table 2-1 Anomalous Single Event Upsets (Continued)

Year	Day	Duration (Hr)	Reset Type	Type SEU
2001	217	6.5	Manual	Sci Telemetry Lockup
2001	306	0.1	Automatic	No WF Update/Rng Sweep
2002	006	2.8	Manual	DFB Interface Lockup
2002	039	1.4	Automatic	Flt SW Corruption
2002	287	0.0	Manual	Bad Data - False Alarm
2002	323	0.0	Automatic	IDLE/Meteor Showers
2003	083	0.2	Automatic	No WF Update/Rng Sweep
2003	090	0.4	Manual	Sci Telemetry Lockup
2003	113	1.3	Manual	Sci Telemetry Lockup
2003	298	6.8	Manual	DFB Interface Lockup
2003	303	0.1	Automatic	Sci Spare Word Corrupted
2003	363	0.1	Automatic	No WF Update/Rng Sweep
2004	194	0.1	Automatic	No WF Update/Rng Sweep
2004	251	2.9	Manual	Sci Telemetry Lockup
2004	252	5.2	Manual	DFB Interface Lockup
2004	272	5.9	Manual	Eng Monitors Corrupted
2004	319	1.1	Manual	DFB Interface Lockup
2005	031	0.8	Manual	DFB Interface Lockup
2005	072	1.5	Manual	Telemetry Corrupted
2005	078	0.6	Automatic	No WF Update/Rng Sweep
2005	153	12.3	Manual	Sci Telemetry Lockup
2005	176	0.1	Automatic	No WF Update/Rng Sweep
2005	255	0.1	Manual	Clear Several ACME Alarms
		Total = 93.7 Hrs		

2.3 Side B Key Events

NASA Altimeter Side B - Key Events are listed in Table C-2 of Appendix C that summarizes the key events for Side B that occurred since the turn-on to the end-of-mission in 2005. Table C-1 lists the key events for Side A.

The listing of key events includes CalSweeps. In response to the altimeter's PTR change during Side A, a CalSweep software patch was developed, and was uploaded on day 250 of 1998. The purpose of this patch was to monitor the shape of the altimeter's CAL1 waveform, looking for changes over time. Beginning with Side A on day 251 of 1998, and continuing until day 223 of 2002, CalSweeps were regularly performed every 30 days. Beginning with day 223 of 2002, CalSweeps were performed every 10 days in an effort to better understand the recent observed irregular CAL1 Ku-band range oscillations. The results of the Side B CalSweeps are discussed in Section 3.3.

2.4 Side B Abnormalities

2.4.1 Land-to-Water Acquisition Times

Early in the Side B Mission, there were occasional slow land-to-water acquisition times, first reported in Section 2.6 of the "TOPEX Radar Altimeter Engineering Assessment Report, Update: Side B Turn-On to January 1, 2000." The anomaly affected only about 0.02% of the potentially available ocean data; it was then last observed during day 243 of 1999.

Since that time, a monitor of the land-to-water acquisition times was used and the AGCMIN15 parameter file was used for flight operations.

Global plots of acquisition anomalies are depicted by the black lines in Figure 2-18 (Cycle 455 in January 2005), Figure 2-19 (Cycle 466 in May 2005), and Figure 2-20 (Cycle 477 in August 2005).

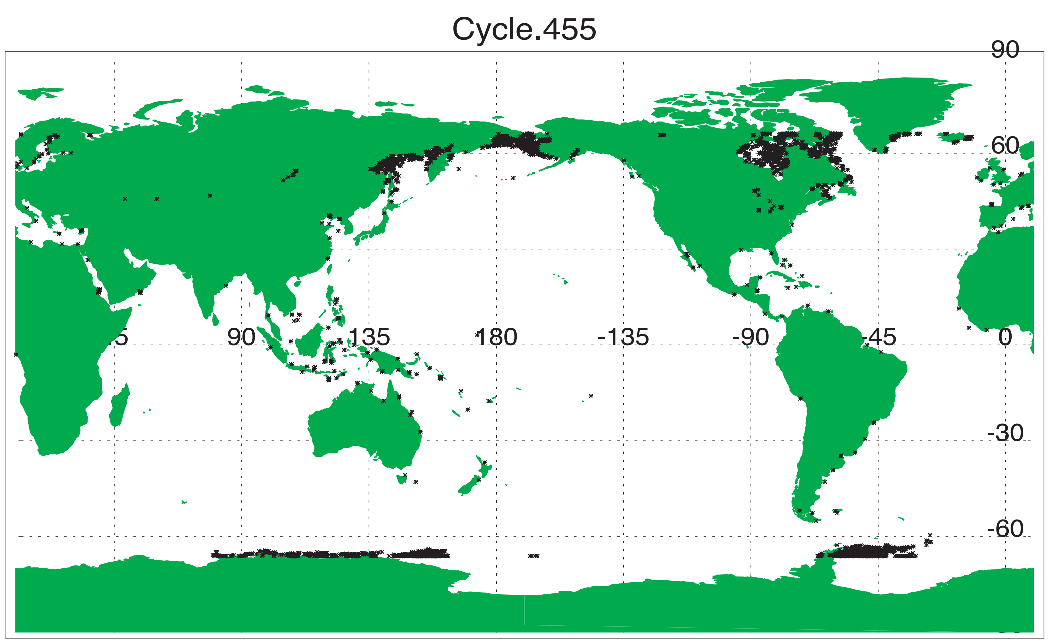

Figure 2-18 Cycle 455, with Areas of Land-to-Water Acquisition Anomalies

There were no slow acquisitions observed in these recent cycles of this year. Their previous occurrences and durations represent a smaller magnitude of potentially available ocean data than in 1999, and do not significantly impact the amount of data collected by the altimeter.

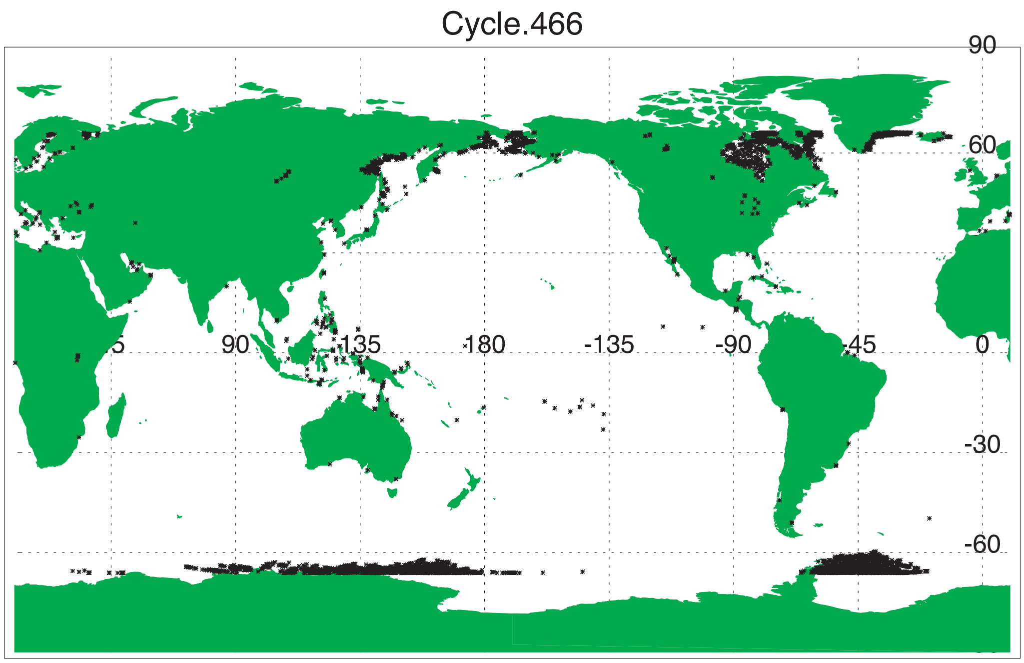

Figure 2-19 Cycle 466, with Areas of Land-to-Water Acquisition Anomalies

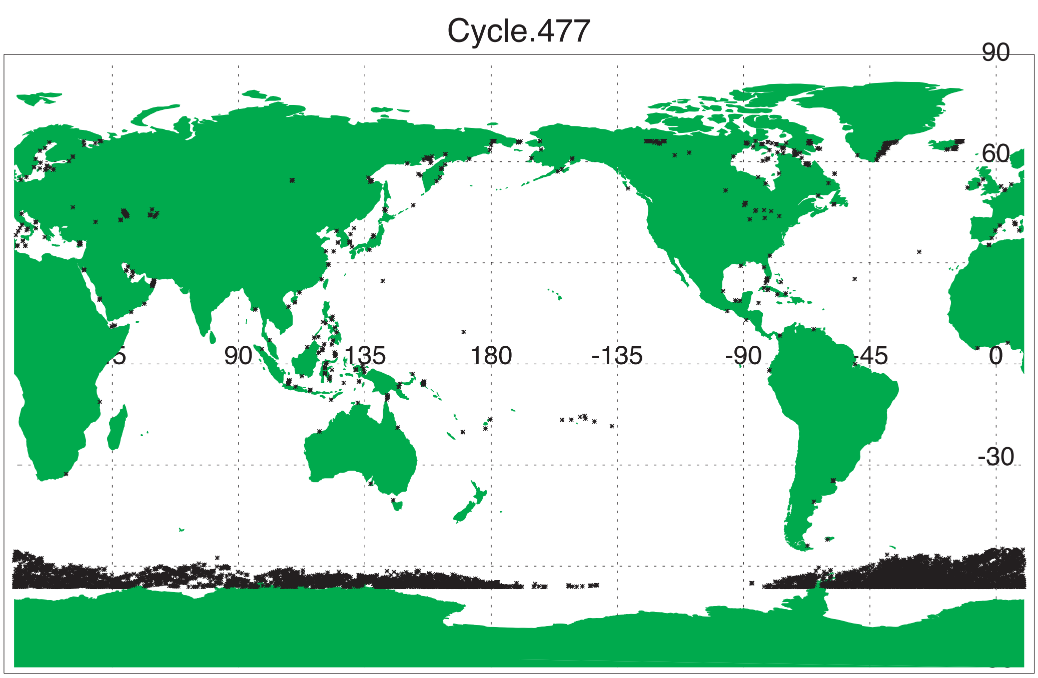

Figure 2-20 Cycle 477, with Areas of Land-to-Water Acquisition Anomalies

2.4.2 Attitude Anomalies

Short-duration attitude excursion anomalies, with maximum attitudes near 0.2 degree, were initially reported in the "TOPEX Radar Altimeter Engineering Assessment Report, Update: Side B Turn-On to January 1, 2001", and again in the "TOPEX Radar Altimeter Engineering Assessment Report, Update: Side B Turn-On to January 1, 2002". In an e-mail message dated February 6, 2004, Phil Callahan (JPL) attributes these short-duration attitude excursions to solar array thermal snap and to a known problem with the Roll Reaction Wheel motor. The 0.2 degree excursions should be of no consequence to the TOPEX data users, due to the TOPEX off-nadir corrections during ground processing being valid for attitudes out to 0.4 degree.

Starting in 2004 and until the end-of-mission, there were large off-nadir angles that were being caused by the roll reaction wheel. Cycle plots that show data, not in track over the ocean, are reported in the “TOPEX Radar Altimeter Engineering Assessment Report, Update: Side B Turn-On to January 1, 2005.

During 2005, there were still problems with the roll reaction wheel, but these were better controlled by the flight operations team’s use of the “kick start” procedure to quickly restart the reaction wheel.

Section 3

Assessment of Instrument Performance (Cycles 236 through Partial Cycle 481)

3.1 Range

The following range discussion is restricted to TOPEX Side B, from its start at cycle 236 (which started on 1999 day 040) through 2005 day 282 about 40% through cycle 481 and was the last day of data in the entire TOPEX mission. Earlier years' assessment updates supplied cumulative results for Side A from launch to the end of the assessment update period, and the assessment update published in August 1999 provided the entire set of TOPEX Side A results from launch through Side A turnoff on 10 February 1999.

This report section discusses the Side B CAL1 Step-5 Ku- and C-band delta ranges. The Calibration Mode was briefly reviewed in Section 2.1. The Ku- and C-band delta ranges were processed to form a set of delta combined range values, where “combined” refers to the weighted sum of Ku- and C-band delta ranges which compensates for the ionospheric electron path delay. There were about twenty combined delta ranges for each TOPEX cycle, corresponding to two calibrations per day during the 10-day cycle. Early in Side A operation we developed a CAL1 processing scheme to remove the effects of a 7.3 mm range quantization in the TOPEX internal calibration mode. The Side B was almost identical to Side A, the same calibration mode quantization was present in the CAL1 delta range data, and we used the same processing method to remove these quantization effects.

In previous years we found that the Side A delta ranges had a temperature dependence. There were about two dozen different temperatures monitored within the TOPEX altimeter, and it was not possible to determine which of these was the most important to range bias. For our Side A analysis we used the temperature of the upconverter/frequency multiplier unit (the UCFM), designating this temperature as Tu. The Ku-band delta range and the combined delta range varied somewhat with Tu, and we had found a simple quadratic correction of the combined delta range for Tu variation. The Side A assessment updates had tables of the range bias results with and without the correction for Tu, but we recommended that the TOPEX GDR data end user (who did not have easy access to the temperature data) should use the Side A combined delta range results that were NOT corrected for temperature Tu.

3.1.1 C-band Delta Range

For Side B the behavior of delta range with temperature was somewhat different than Side A. We reported two years ago (TOPEX Engineering Assessment Report Update, NASA-TM-2004-212236, Volume 17) that the C-band result exhibited a temperature dependence somewhat more highly correlated with the receiver AGC temperature (designated Tagc here) than with Tu. This continued to be the case. Figure 3-1 shows the full-rate Side B Tagc values through the end of cycle 452, and Figure 3-2 shows

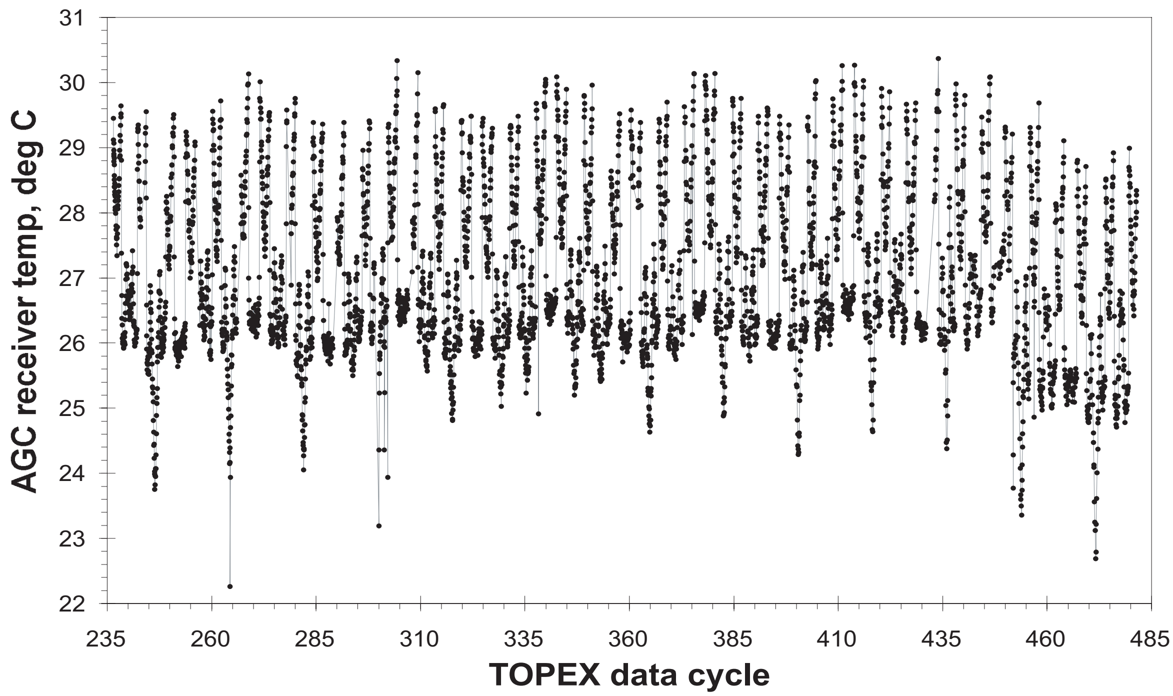

Figure 3-1 Side B AGC Receiver Section Temperature

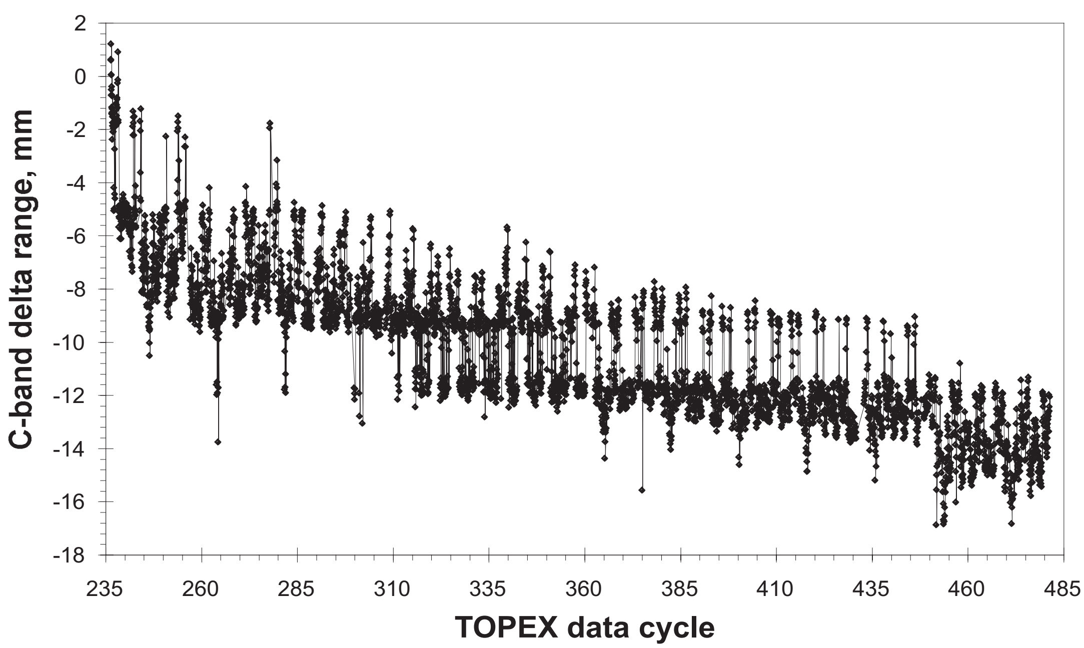

Figure 3-2 Side B CAL1 Step-5 C-band dRange vs. Cycle NOT Corrected for Temperature

full-rate Side B C-band CAL1 Step 5 delta range values. Some of the “spikes” in the C-band delta range of Figure 3-2 can be removed by assuming a quadratic dependence of delta range on Tagc and doing a simple least-squares fit to find the coefficients for the quadratic dependence. Figure 3-3 shows the Side B C-band delta range

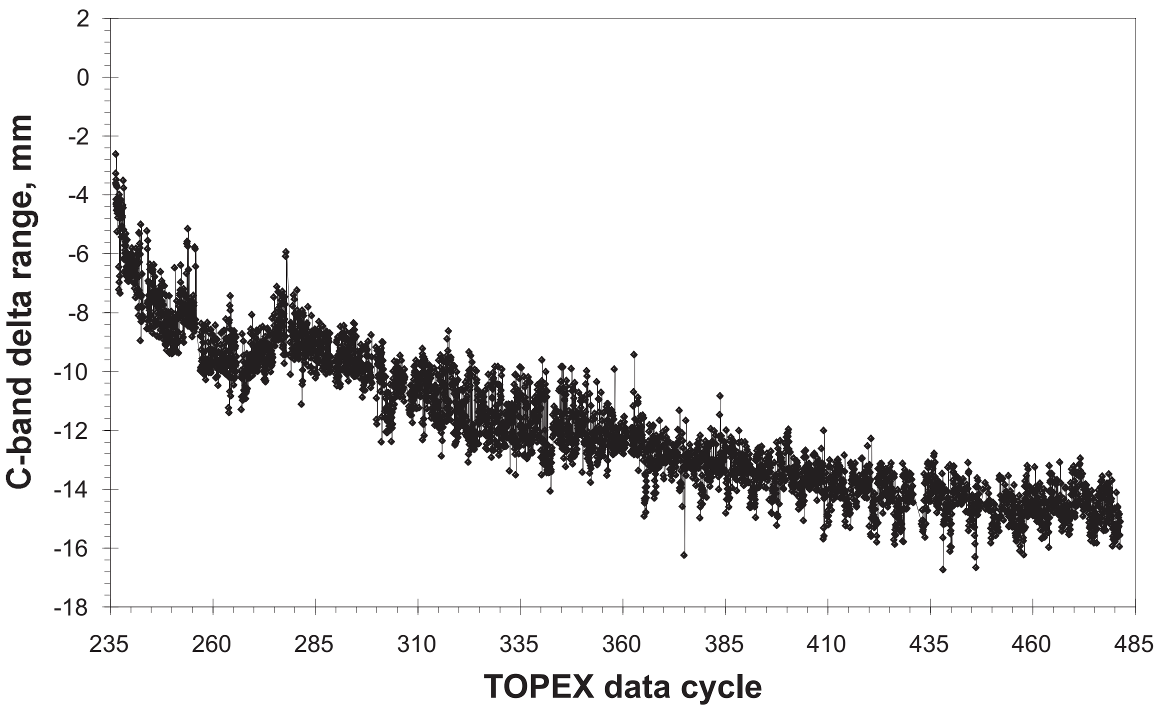

Figure 3-3 Side B CAL1 Step-5 C-band dRange vs. Cycle WITH Correction for Receiver AGC Temperature

after making the quadratic correction for the Tagc, and it can be seen that the Tagc correction term does eliminate some of the variations in Figure 3-2 of the individual data relative to the general trend.

3.1.2 Ku-band Delta Range

Figure 3-4 and Figure 3-5 show the Side B Ku-band CAL1 Step 5 delta range values for the same time span, before and after removing a quadratic correction for Tagc. It can be seen that the Tagc correction has a visible but small effect on the results. A noticeable feature in Figure 3-4 and Figure 3-5 is the change of character of the Ku-band CAL1 delta range with the onset of “toggling” early in cycle 364 and continuing through cycle 460 or so. After cycle 460, the toggling is still present but seems less frequent than in the interval from cycle 365 through 460. It is possible that the altimeter drifted almost through the toggling region such that by cycle 480 it disappeared completely. We will never know that however, as the TOPEX data stopped part way through cycle 481 because of the loss of spacecraft attitude control. Similar calibration mode range toggling was seen in TOPEX ground system pre-launch testing during some temperature transitions as well as some plateau temperature tests. At that time our processing did only least significant bit (LSB) conversion so we saw about 7 mm

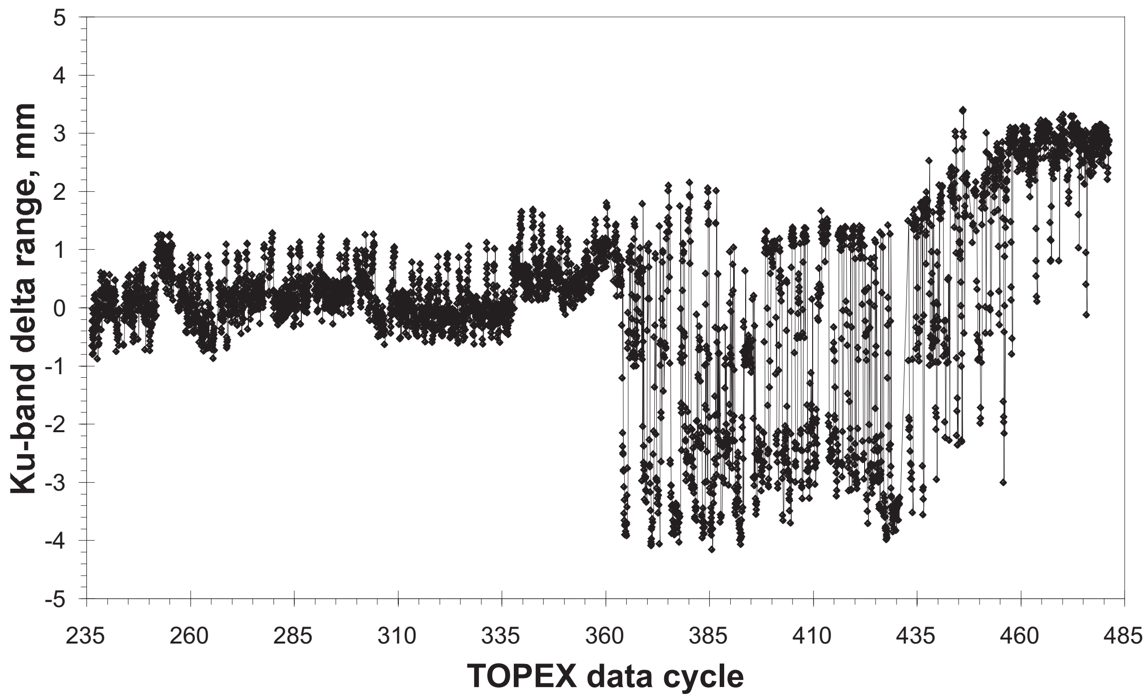

Figure 3-4 Side B Ku CAL1 Step-5 dRange vs. Cycle with NO Temperature Correction

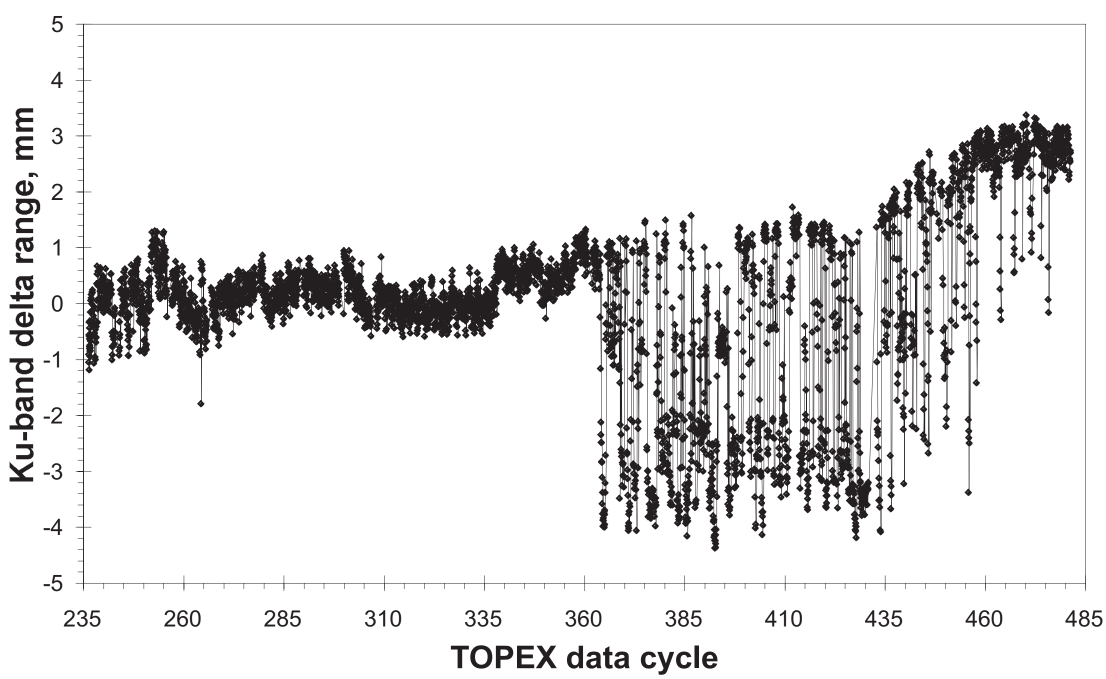

Figure 3-5 Side B Ku CAL1 Step-5 dRange vs. Cycle WITH Correction for Receiver AGC Temperature

toggles. Since that time we implemented a more precise algorithm that reduced the LSB resolution to about 2 mm (see Section 2.1.1, TOPEX Mission Radar Altimeter Engineering Assessment Report Update, March 1995, NASA/TM -2003-212236, Volume 8). The toggling behavior in the ground testing was traced to probably being a thermal characteristic of a component in the MTU which had a nonlinear function in a specific temperature range. In the region of 30 degrees C, there were toggle steps in the MTU component's output that the engineering team reported would cause the range toggling.

The pre-launch investigation concluded that the effect was not a problem since it was within the TOPEX specification, the range repeatability was within specification, and the engineering team was confident there were no parts reliability problems associated with the characteristic. The Side B calibration mode range at the MTU RF preamp temperature range 31 to 33 degrees C had toggle steps in the output that were similar to that seen in-flight. It was the Wallops' team feeling that in-flight, the TOPEX altimeter Side B had aged such that the MTU component operated on the edge of this toggle zone.This type of shift in hardware characteristics was not uncommon in ground based radars. Our analysis showed no significant effect on the TOPEX range performance, and we had no concerns about any reliability issues. Nothing could be done to remove or compensate for the toggling in the CAL1 Ku delta height if it was coming from this device. In Figure 3-3 and other figures showing CAL1 ranges with correction for the receiver AGC temperature, the Tagc corrections were based on fits to results from cycles 236 through 363, the Side B data period before the onset of the toggling.

3.1.3 Combined Delta Range

Figure 3-6 and Figure 3-7 compare the Side B combined delta range results before and after Tagc corrections, and the Tagc corrections had only a very small effect. Because the combined delta range was a weighted sum of the Ku- and C- band ranges, with relative weights of approximately +7/6 and -1/6 respectively, the combined range shows toggling similar to the Ku-band range.

3.1.4 Cycle-Averaged Delta Range

As determined previously for Side A, the Side B general trend of delta ranges was sufficiently slow that corrections could and should be made based on cycle averages of the CAL-based delta ranges. Figure 3-8 and Figure 3-9 respectively show the Side B C-band cycle averages of the delta height with no temperature correction applied and with Tagc temperature correction applied. Similarly, Figure 3-10 and Figure 3-11 show the Side B Ku-band cycle averages of the delta height without and with Tagc correction, and Figure 3-12 and Figure 3-13 show the set of cycle averages of the combined height delta ranges without and with the Tagc correction.There was little apparent benefit to using the Tagc correction for the combined delta range, and the Tagc was not available on the TOPEX GDR data product, so we strongly recommended using the Side B combined delta ranges with NO temperature correction.

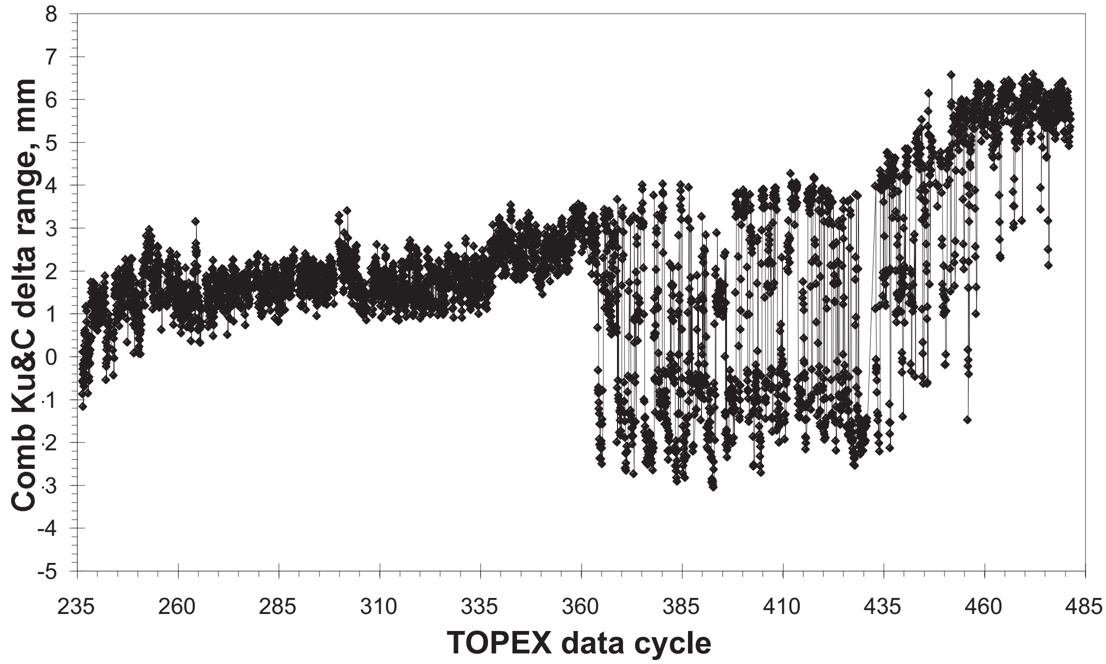

Figure 3-6 Side B CAL1 Step-5 Combined dRange vs. Cycle with NO Temperature Correction

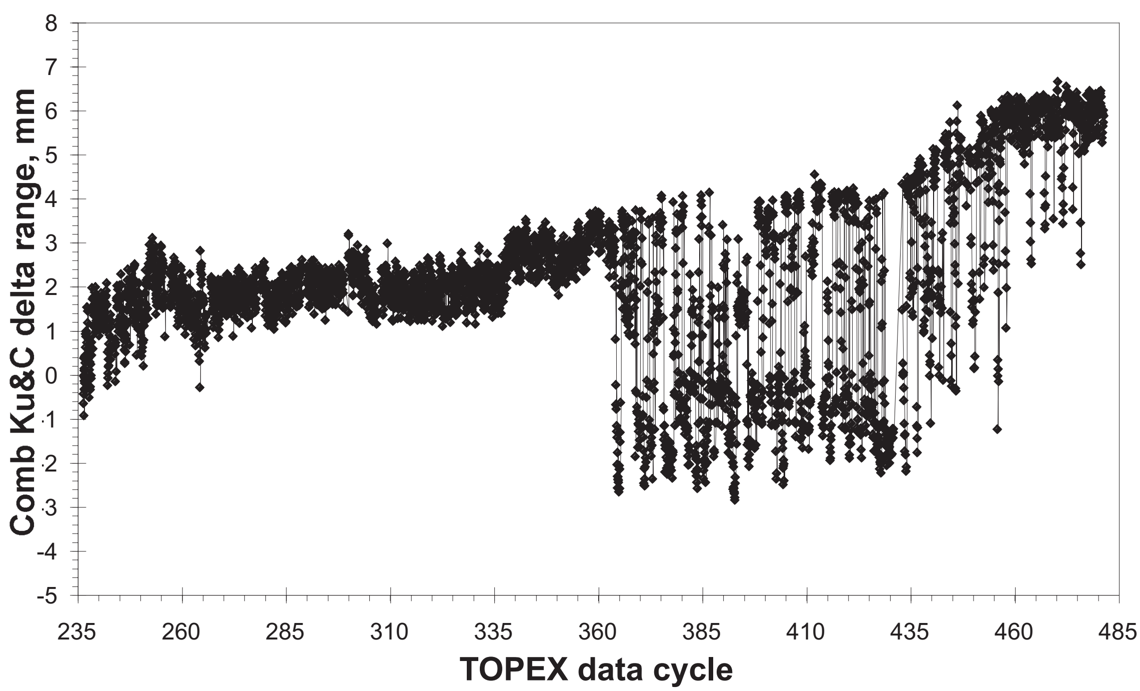

Figure 3-7 Side B CAL1 Step-5 Combined dRange vs. Cycle after Correction for Receiver AGC Temperature

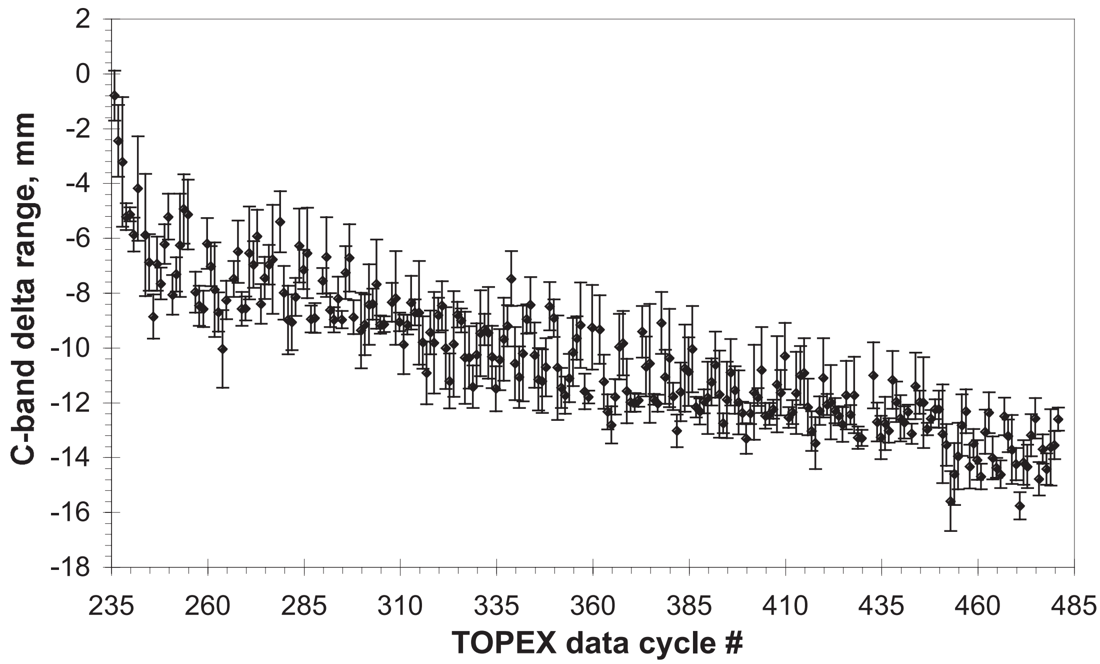

Figure 3-8 Side B C-band Delta Range vs. Cycle Not Corrected for Temperature

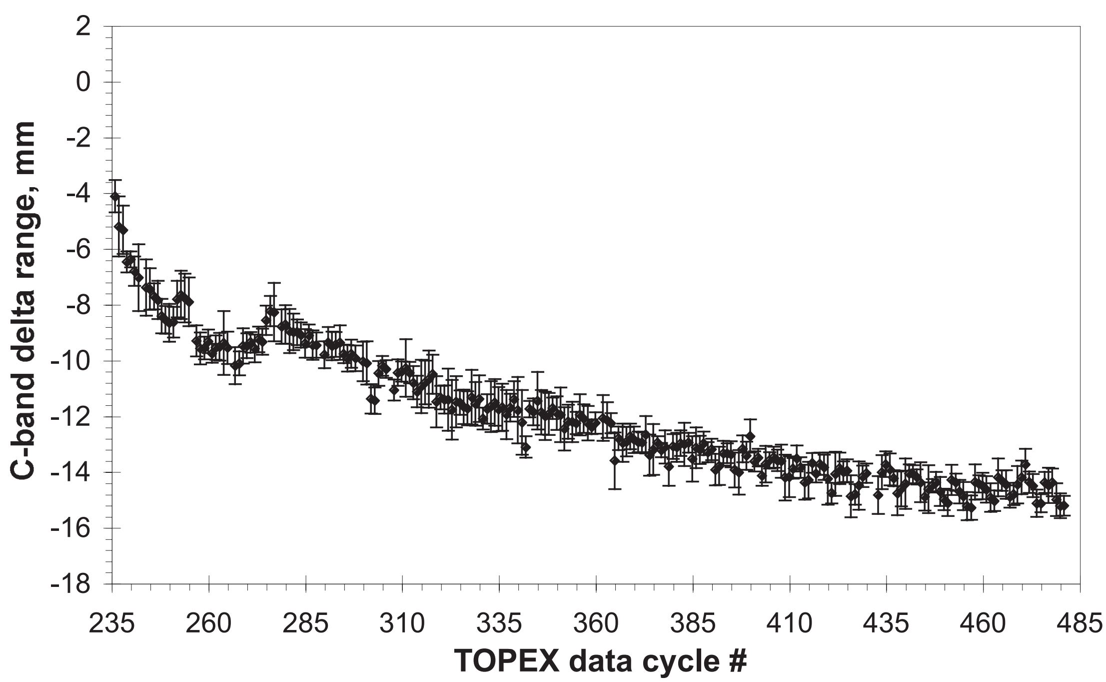

Figure 3-9 Side B C-band Delta Range vs. Cycle With Correction for Receiver AGC Temperature

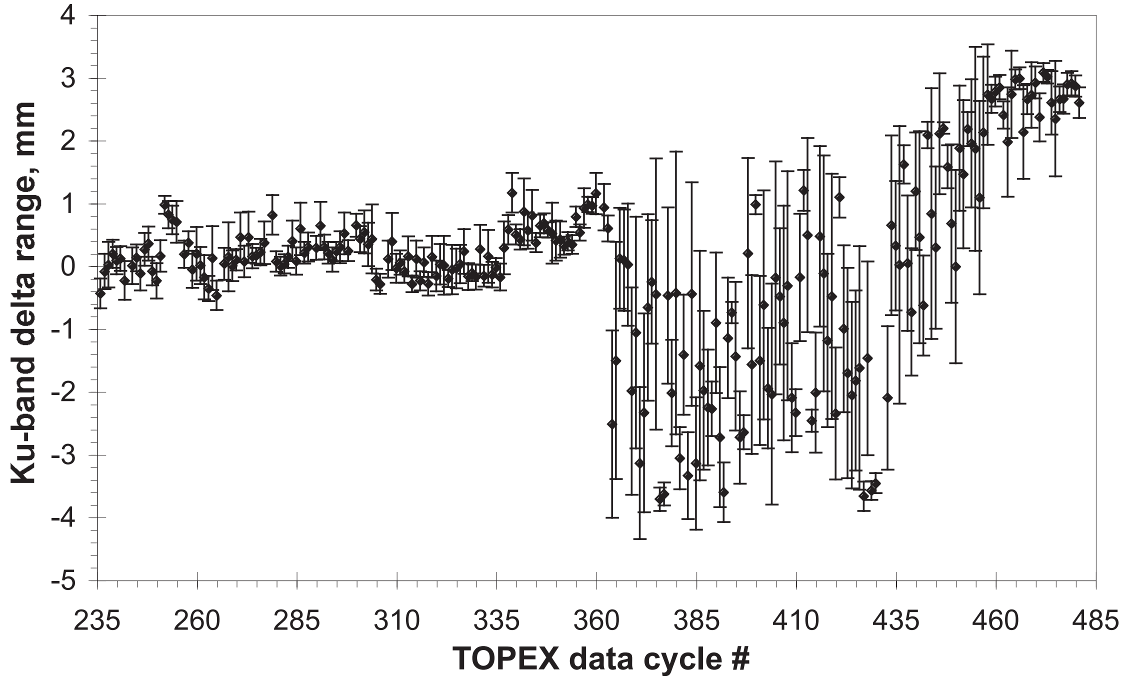

Figure 3-10 Side B Ku-band Delta Range vs. Cycle Not Corrected for Temperature

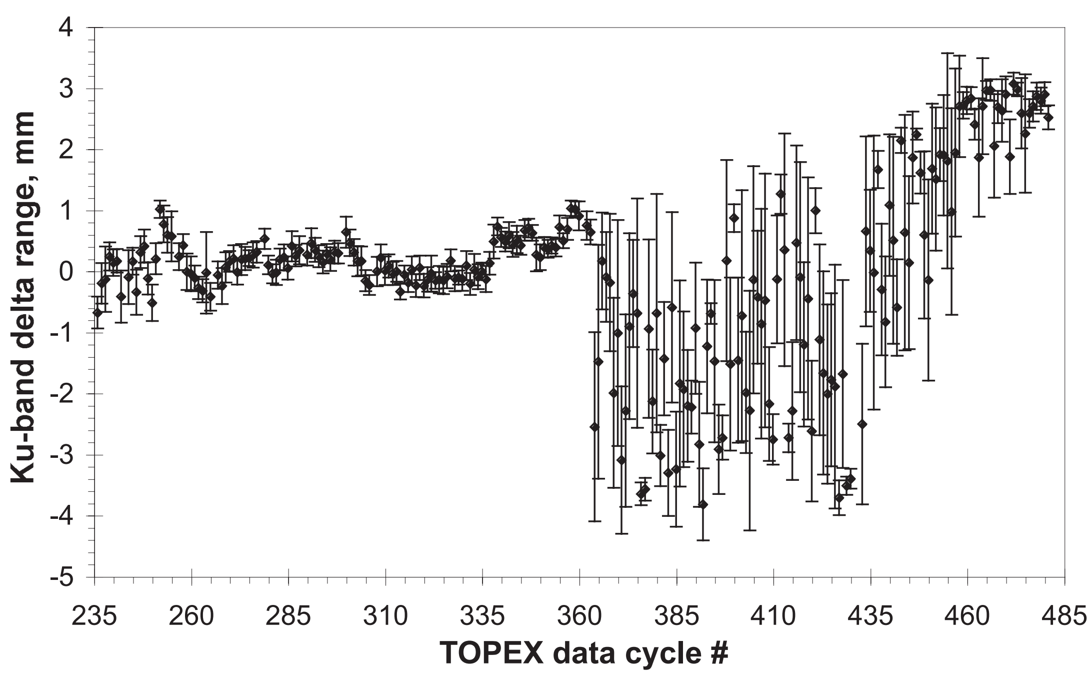

Figure 3-11 Side B Ku-band Delta Range vs. Cycle With Correction for Receiver AGC Temperature

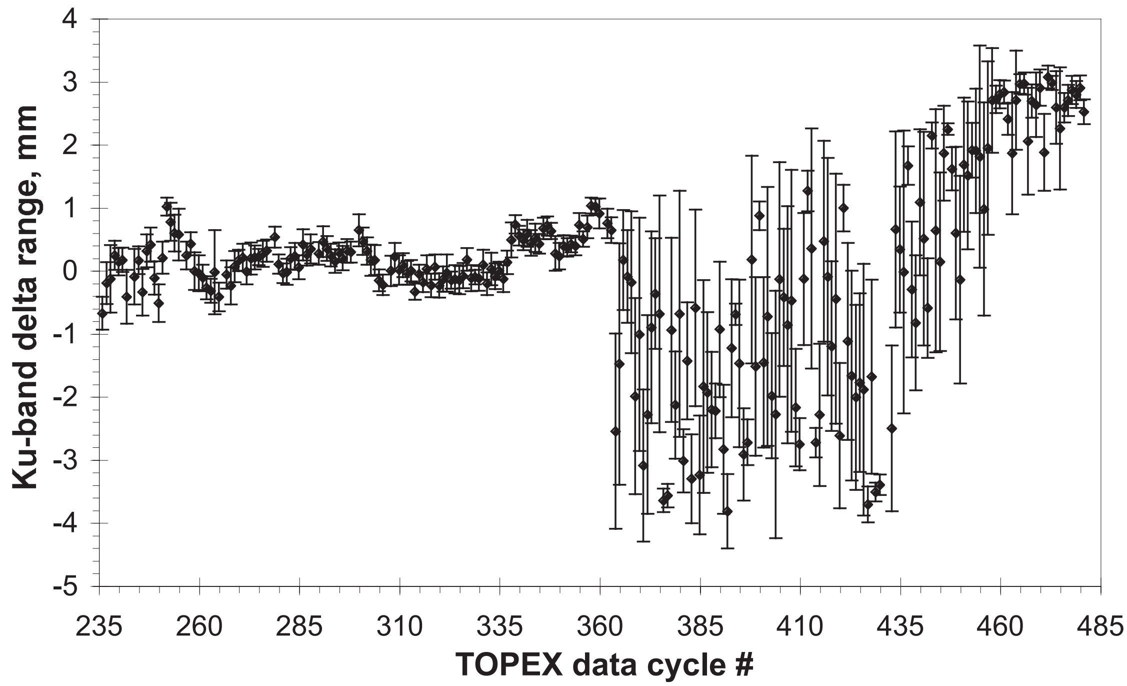

Figure 3-12 Side B Combined (Ku & C) Delta Range vs. Cycle Not Corrected for Temperature

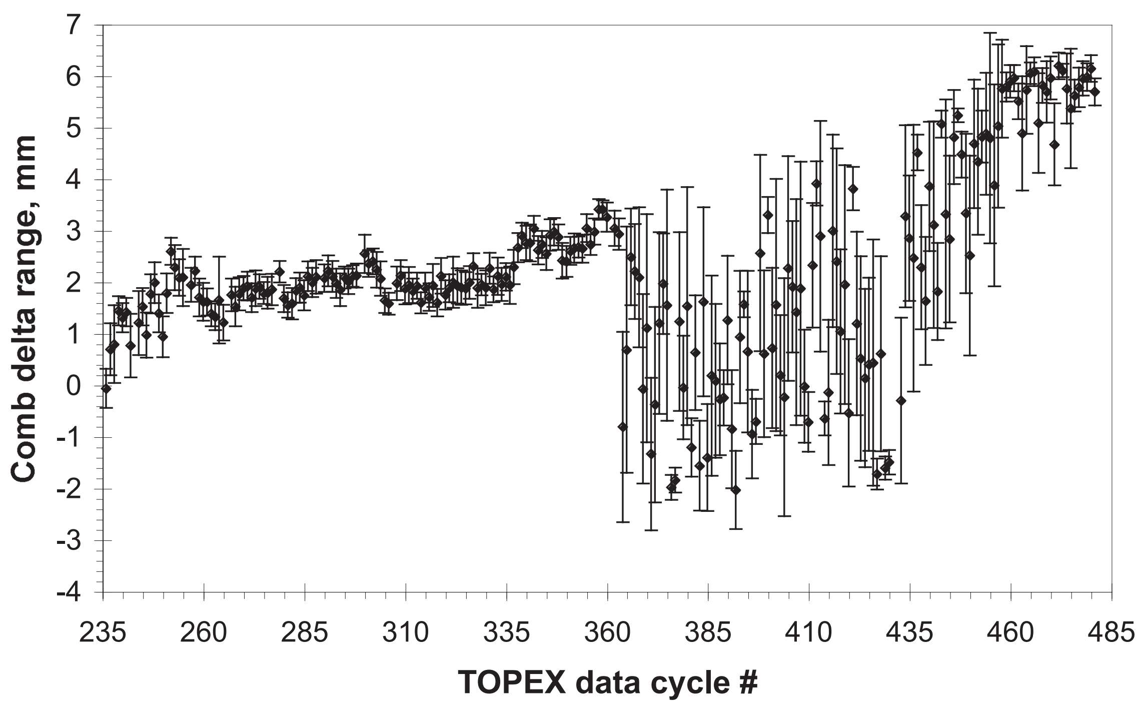

Figure 3-13 Side B Combined (Ku & C) Delta Range vs. Cycle With Correction for Receiver AGC Temperature

Figure 3-14 plots the cycle-averaged combined delta range (with no temperature correction) for all TOPEX cycles from start of mission through the partial cycle 481, so that the Side A and Side B behavior could be compared. These cycle-averaged delta range values are printed in Appendix H, Table H-1, and are also available at our TOPEX web site http://topex.wff.nasa.gov (select "Range Stability" from side menu).

The web site table also has the delta ranges which are temperature corrected for Tu using the correction developed for Side A. It was incorrect to calculate the Side A correction for the Side B data on the web site, and the Tu correction should be ignored. The simple guideline for Side B was to use the delta range that has NO temperature correction.

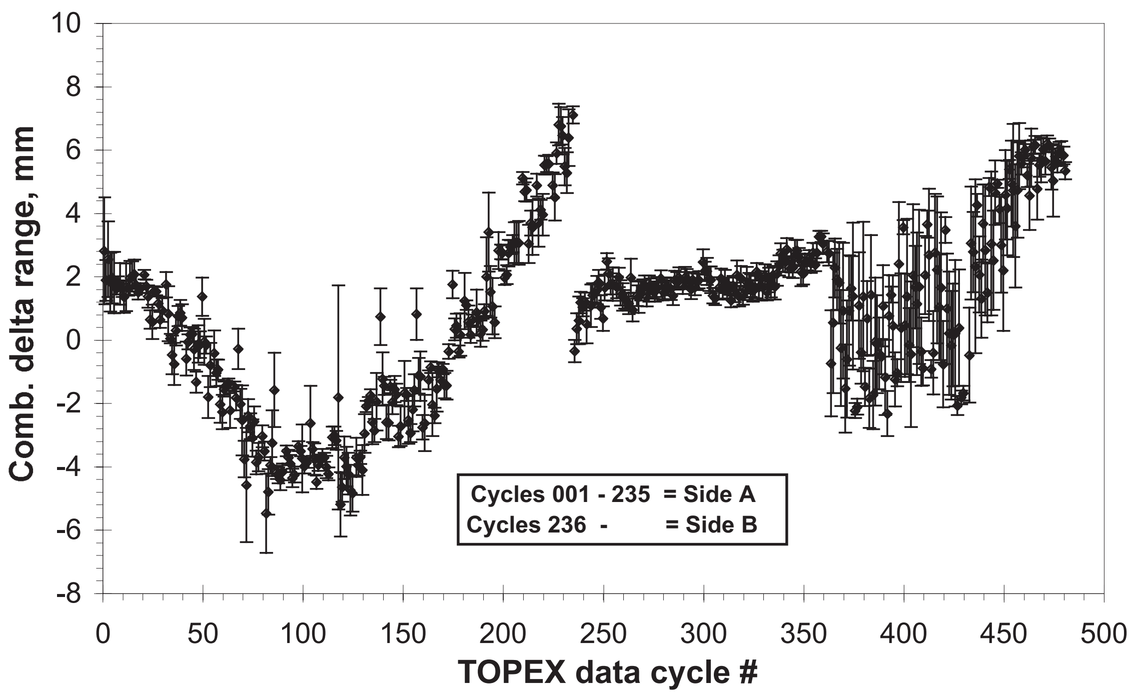

Figure 3-14 Combined (Ku & C) Delta Range vs. Cycle Not Corrected for Temperature

To correct the GDR range data for the range calibration drift, one would use

Corrected Range = GDR range - dR_av_N,

where dR_av_N is the cycle-average delta combined range value of Table H-1 in Appendix H. Note that the delta ranges were all given relative to a constant but arbitrary range offset, so this correction provided only a relative range drift correction. The corresponding expression for correcting the GDR sea surface height (SSH) is

Corrected SSH= GDR SSH + dR_av_N.

To return briefly to the Ku-band CAL1 delta range toggling described earlier in this report section, we do not know the reason for this change in TOPEX Side B Ku-band

CAL1 delta range behavior which became apparent early in cycle 364 and continued through cycle 460, possibly lessening in the interval from cycle 460 to 481. We have been unable to find any useful correlation of this Ku-band CAL1 range toggling with any of the temperatures, voltages, and powers available in the TOPEX engineering telemetry.

At one time, shortly after the onset of the toggling behavior, we thought that we saw a correlation between the Ku delta range and AGC temperature Tagc. As we examined more data after toggling onset however, we saw that the correlation between Ku delta range and Tagc seemed to change over the time of Side B operation. Last year we calculated and reported the value for the correlation between the Ku delta range and Tagc, and now we repeat that correlation calculation to include the additional 29 or so cycles of TOPEX data in calendar year 2005. A width of 81 data points were used in the correlation calculations, and Figure 3-15 shows the centered 81-point cor-

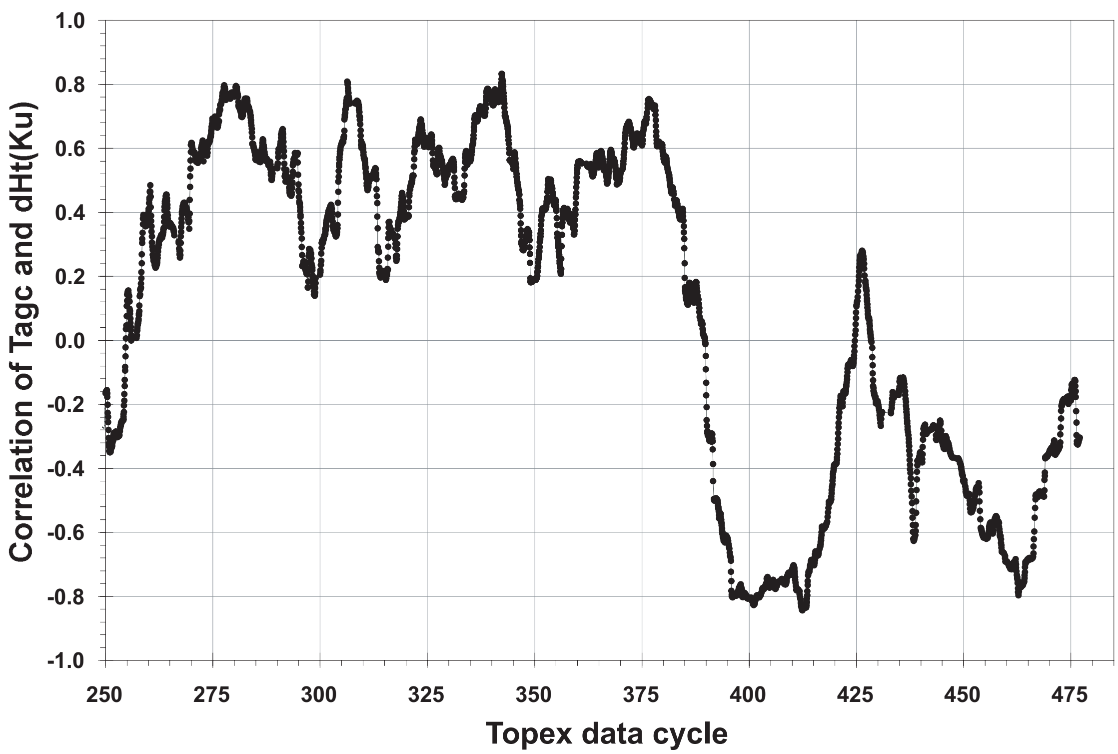

Figure 3-15 TOPEX Tagc:dH(Ku) Correlation vs. Cycle for 161 Data Points in Correlation (~ +/- four cycles)

relation values plotted vs. data cycle. Figure 3-15 shows the centered 81-point correlation values plotted vs. data cycle. The figure indicates that the Tagc:dH(Ku) correlation values did not change appreciably at cycle 364, the cycle of onset of the toggling behavior. The correlation values were positive and generally between 0.2 and 0.8 for cycles up to about cycle 380. By cycle 395, however, the correlation had become negative with values generally between -0.65 and -0.85. By cycle 425 the correlation became positive with a value around 0.2, but then the correlation went negative again with a minimum around cycle 460 before moving again toward zero. The 81-point computation width was arbitrarily chosen, and the appearance of Figure 3-15 might be expected to change if the number of points used in the correlation calculation was changed. We varied the computation width and found that the correlation curve became somewhat smoother as the computation width was increased, but that the general trend remained the same as Figure 3-15. This was consistent with the suspicion that the toggling was coming from the MTU component as described in a preceding paragraph. Our conclusion was that there was no conceivable way to use Tagc to build any sort of correction procedure to compensate for the delta Ku range toggling.

3.2 AGC/Sigma0

The ocean surface's radar backscattering cross section, one of the quantities estimated by the TOPEX radar altimeter, was designated for typographical convenience often as sigma0 or sigma-naught; in this report section we will use sigma0. Most altimeters will eventually drift in their power estimation and hence in their sigma0 estimation. To correct for such drift, the TOPEX ground data processing included a lookup table of sigma0 corrections. We will refer to that table as the “Cal Table” (the relevant TOPEX ground data processing system filename is SPA_ALT_CALPAR.TXT). Before launch we expected that the Cal Table would be based on AGC data in the internal CAL1 mode (see Section 2.1). However, in Side A it became apparent that the sigma0 trends deviated somewhat from the CAL1 AGC trends, and we began producing Cal Table entries based on the long-term trends of the over-ocean sigma0 data. In this section we describe the sigma0 trends from start of Side B (cycle 236) through partial cycle 481, the cycle in which the satellite's attitude control system failure ended the TOPEX mission data. Our sigma0 trend analyses used the sigma0 before the Cal Table corrections were applied, and we refer to this as sigma0_uncorr or as uncorrected sigma0.

3.2.1 Processing of Calibration Mode Results and Global Sigma0 Averages

As part of our TOPEX support, we did daily quick-look processing of all TOPEX altimeter data for performance monitoring, providing performance summaries for the engineering and science data. These daily processing results were used to update a launch-to-date engineering database. Also, data were processed from the twice-daily execution of the altimeter's internal calibration mode (with submodes CAL1 and CAL2) and these results were used to update a WFF launch-to-date calibration database. We also processed the intermediate geophysical data record (IGDR) data as they became available for network access, normally several days after the altimeter acquired the data. The IGDR data were processed for altimeter performance, and 1-minute summary records were produced and added to a WFF launch-to-date GDR database. When the final GDR data became available, they replaced the IGDR data already in our database. There was no difference however between sigma0 data on the IGDR and the GDR, because no further sigma0 corrections were made in going from the IGDR to the GDR.

We had been very concerned about possible contamination of the data by what we called "sigma0 blooms", regions of over-ocean altimeter data characterized by unusually high apparent sigma0 values accompanied by unusual altimeter waveform shapes. Generally the Ku-and the C-band sigma0 showed the same behavior in a bloom region. Such blooms in the TOPEX data could persist for several tens of seconds, and the waveforms in a bloom region generally had too rapid a plateau decay. Many of these waveforms were too sharply peaked ("specular"), indicating a breakdown in the general incoherent scattering theory used to characterize the rough surface scattering. The sigma0 blooms existed in perhaps 5% of all TOPEX over-ocean data (additional sigma0 bloom information can be found at http://topex.wff.nasa.gov/blooms/blooms.html). Further characterization of the sigma0 blooms is provided in Mitchum et al (2004). As input constraints to our GDR database 1-minute averages, we required all the available altimeter flags to show normal tracking and the land/water flag to show deep water. When the data were extracted from this database for the sigma0 calibration, all records were rejected having Ku-band sigma0 estimates of 16 dB or greater or having waveform-estimated attitude angles of 0.12 degrees or greater. These editing criteria deleted most of the sigma0 blooms.

Because our analysis was based on sigma0_uncorr, we needed to know what Cal Table values were already applied to the GDR (or IGDR) data in order to "undo" these corrections. The report from two years ago, TOPEX Radar Altimeter Engineering Assessment Report Update - Side B Turn-On to January 1, 2004, Vol. 18, NASA/TM-2004- 212236, provided a history of the Side B sigma0-related Cal changes. TOPEX operated very stably for all of year 2005 (until its data ended) with no significant drifts evident in the Ku- and the C-band Cal Table corrections, and no sigma0-related Cal Table updates were made since last year's report. Rather than repeat this unchanged information here, we refer the reader back to that report's sections 3.2.2 and 3.2.3 and its Table 3-2. (There was one Cal Table change, changing the slope of the predicted correction trends for Ku- and C-band, which was made around year 2004 day 157. This change was inadvertently left out of the discussion in the report two years ago, and is reported here for completeness. There were no Cal Table updates in all of year 2005 as stated above.)

3.2.2 Latest Fitted Sigma0 Trends for Estimation of Cal Table Values

Figure 3-16 shows the TOPEX Side B Ku-band CAL1 and CAL2 delta AGC cycle averages (with the Cal Table corrections removed) and the Ku transmitter power monitor cycle averages plotted vs. cycle number. By delta AGC we mean the AGC values relative to a constant reference level. Notice that the CAL2 delta AGC and the transmitter power monitor values were shifted to use a common vertical plot axis.

Figure 3-17 shows the corresponding data for the TOPEX Side B C-band altimeter. The Ku-band, Figure 3-16, suggests a step change in both the CAL1 and CAL2 delta AGC data following the TOPEX safe hold which occurred during cycle 256, while the

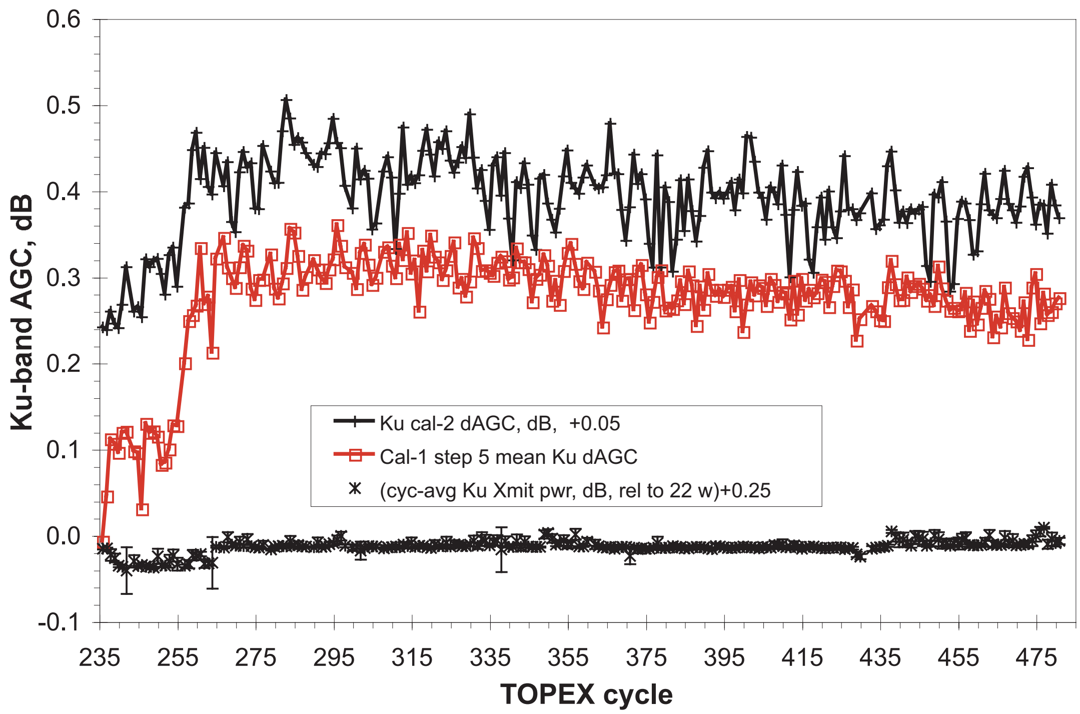

Figure 3-16 Ku Side B Cycle-Avg CAL1 & CAL2 Delta AGC (Cal Table Corrections Removed)

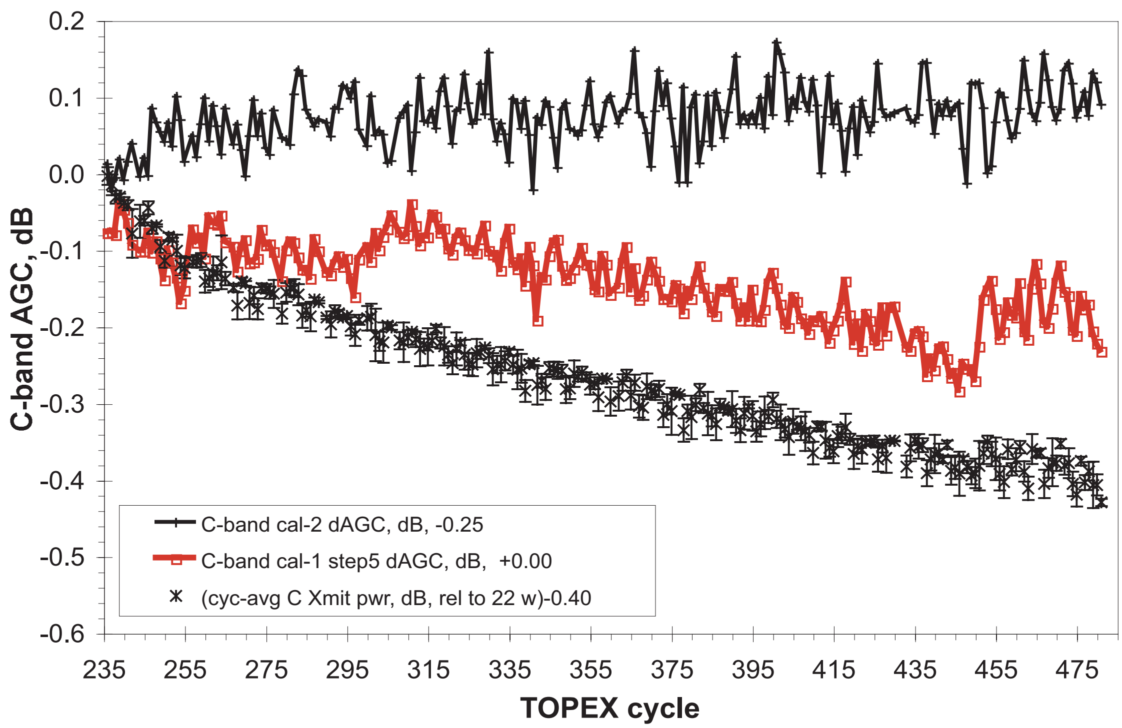

Figure 3-17 C-band Side B Cyc-Avg CAL1 & CAL2 Delta AGC (Cal Table Corrections Removed)

transmitter power monitor shows almost constant data from the start of Side B operation (beginning with cycle 236) through the partial cycle 481 (the cycle in which the satellite's attitude control system ceased operating). The C-band, Figure 3-17, however, showed no step in the delta AGC data, but did indicate a general downward trend in the transmitter power monitor data.

Next, Figure 3-18 plots the Side B Ku-band cycle averages of CAL1 delta AGC and of over-ocean sigma0 vs. cycle. Notice that both curves showed a similar step change at cycle 256. Figure 3-19 plots the corresponding C-band data, and did not show a step change at cycle 256 but did show a divergence of the two curves at higher cycle number. For the sigma0 data in Figure 3-18 and Figure 3-19 and for the following sigma0 trend fits in this section, we first applied to the uncorrected sigma0 an empirical seasonal correction which was based on the Side A data from cycles 17 through 235.

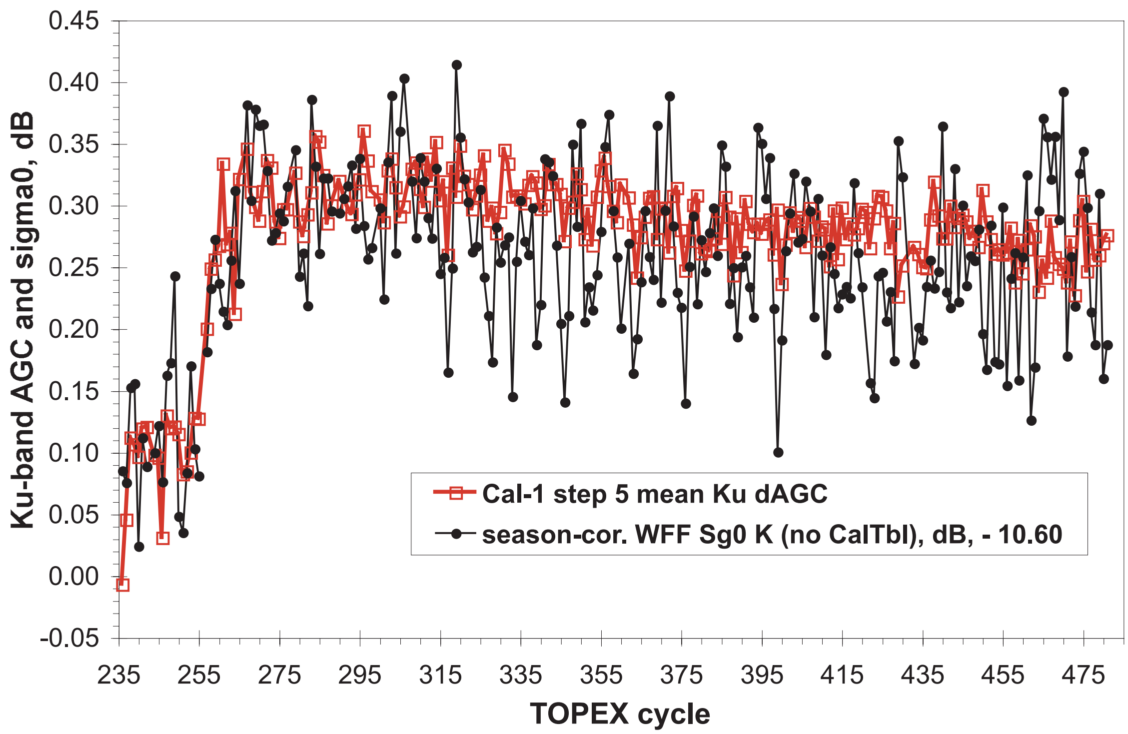

Figure 3-18 Ku Side B Cycle-Average CAL1 Delta AGC and Sigma0 (Cal Table Corrections Removed)

Figure 3-20 plots the differences of the Ku-band data of Figure 3-18 and of the C-band data of Figure 3-19. Figure 3-20 also plotted the results of a low order polynomial fit to the difference data. Interestingly, the Ku-band step change at cycle 256 disappeared in this Ku-band difference plot, while the C-band difference plot showed a decay with increasing cycle number which was similar to the rate of decay of the C-band transmitter monitor. After the end of the TOPEX mission, it may be possible to remove the Figure 3-20 trends from the CAL1 delta AGC data and then use these

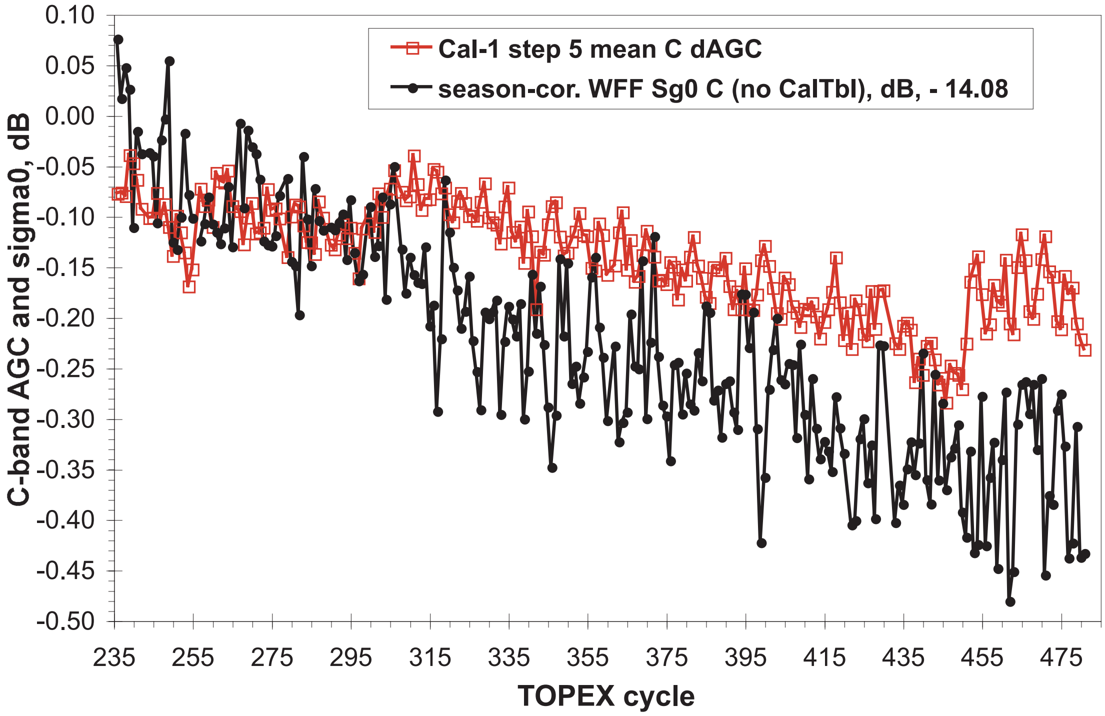

Figure 3-19 C-band Side B Cycle-Avg CAL1 Delta AGC and Sigma0 (Cal Table Corrections Removed)

detrended CAL1 data for a final Cal Table for reprocessing all the Side B sigma0 data. We cannot use this approach until the end of mission, however, because we have to be able to project the Cal Table sigma0 values ahead by at least 10 cycles, so we use a set of fitted line segments instead to characterize the sigma0 trends.

Since cycle 300 we have been fitting straight line segments to the Side B sigma0 data with a discontinuity in slope and value of the fit at cycle 256 to allow for the possible step change in altimeter characteristics; the sigma0 data after cycle 256 was modeled by two straight line segments having continuous values but allowing a discontinuity in the slope. The cycle at which the slope changed was one of the variable fit parameters, so the fits consisted of three straight-line segments with the latter two connected to each other. By late in year 2002 however the last of the line segments began to show the need for a higher order fit than linear, so the last (rightmost) of the three linear segments was replaced by the rational polynomial form y = (a0 + a1*x + a2*x2)/(1 + b1*x), where a0, a1, a2, and b1 are fit coefficients and x is data cycle number. The a0 was further constrained by the requirement that the second-to- third segment fit value be continuous. This functional form introduced in year 2002 gave us problems in year 2003; because polynomials are notoriously difficult to use in extrapolations out of the data regions in which they were fitted, so we went back to connected linear segments.

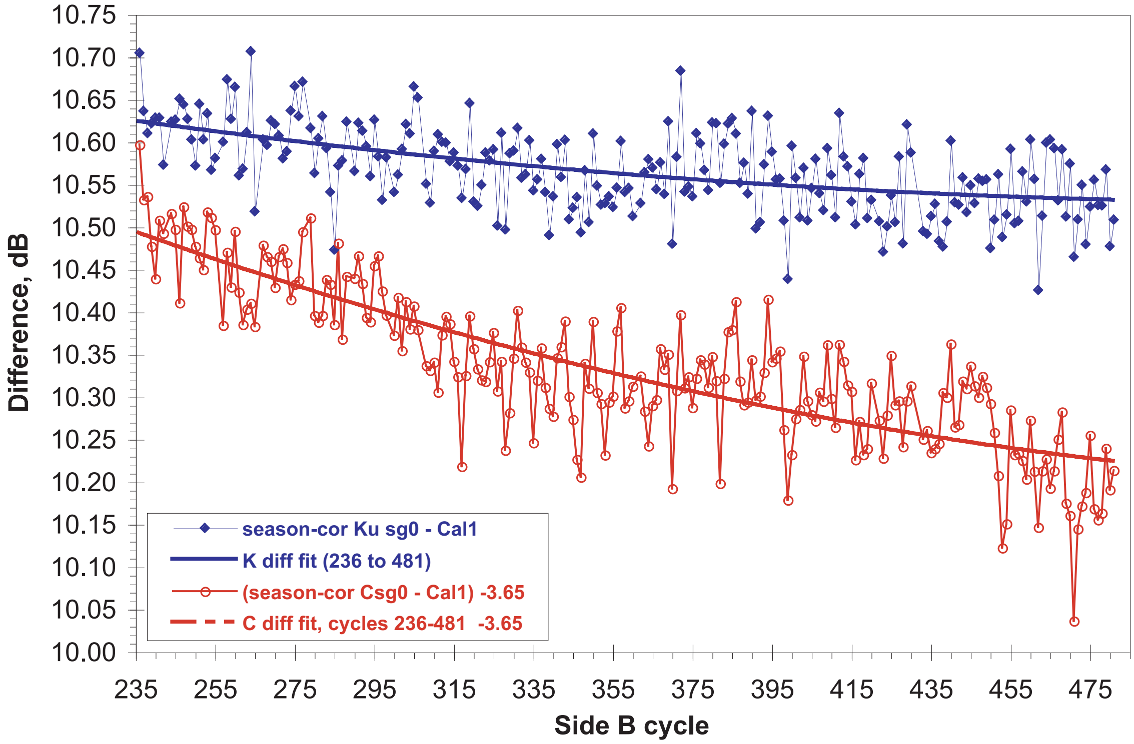

Figure 3-20 TOPEX Side B Diff's, Sigma0 minus CAL1 Delta AGC (sigma0 have CalTable removed and are corrected for seasonal effects)

For now, we're using four line segments, allowing a discontinuity at cycle 256 but requiring the three segments after 256 to be continuous in value (although obviously not in derivative). The slope transition points are varied by the least-squares fit but are subjected to the constraint that no segment can be shorter than 20 data cycles. An additional constraint was that the slope of the rightmost segment should be zero. The resulting trend fits to the Ku- and the C- band seasonally-corrected sigma0 cycle averages are shown in Figure 3-21.

The (negatives of the) Figure 3-21 data provide relative sigma0 corrections, and it was arbitrarily decided to set the relative corrections to zero at cycle 240; that is, we assumed that +0.45 dB was the correct Ku-band Cal Table value and that +0.55 dB was the correct C-band Cal Table value at cycle 240. From the line-segment fits we calculated the values given in the fourth and fifth columns of Table G-1 of Appendix G. These are our best current estimates of the values which should have been in the Cal Table, and if one were to recalculate GDRs one should use these (fourth and fifth column) numbers as replacements for the values used in the original GDR production (given in the second and third columns of the Table G-1).

The sixth and seventh columns in Appendix G, Table G-1 give the (additive) amounts by which the already-distributed Ku- and C-band sigma0 values can be adjusted for the new fitted Cal Table values. The old Cal Table values and the fitted new Cal Table

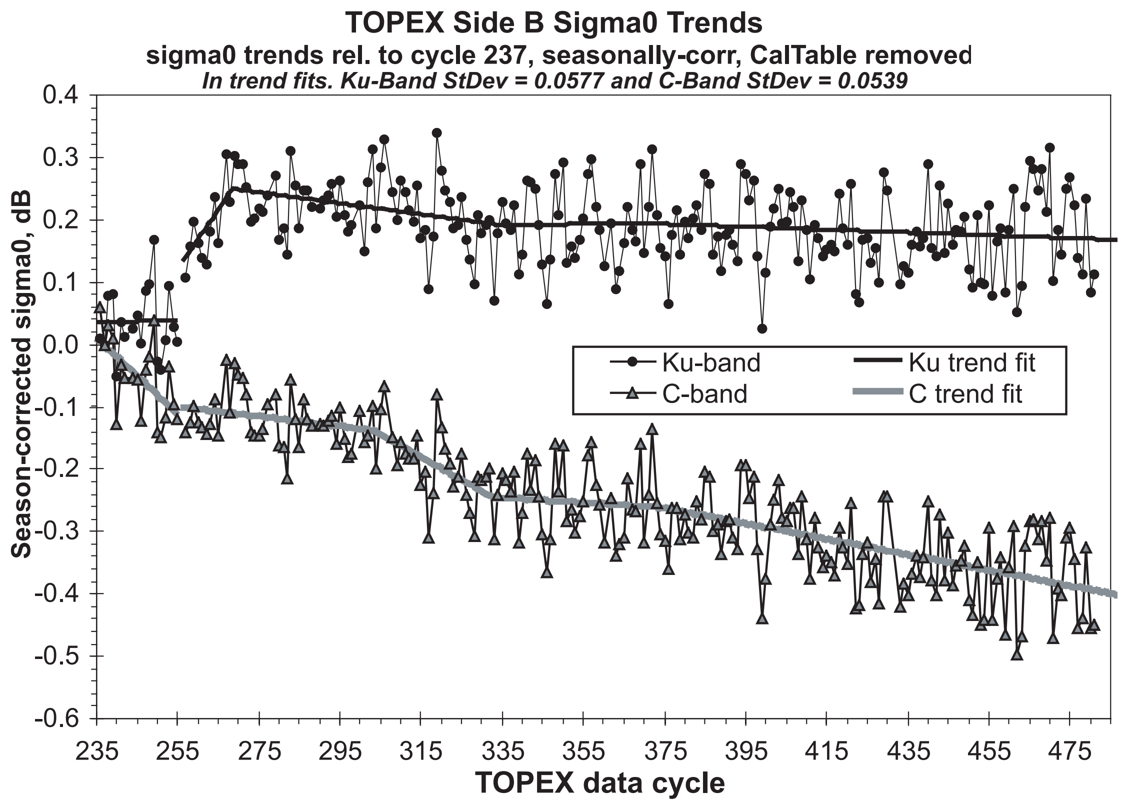

Figure 3-21 TOPEX Side B Sigma0 Trends
(sigma0 trends rel. to cycle 237, seasonally-corr, CalTable removed)

values are plotted for Ku-band in Figure 3-22 and for C-band in Figure 3-23. Figure 3-24 shows the trend fit adjustments to already-distributed Ku- and C-band sigma0. The Ku-band sigma0 values for cycles 257 and 258 are the most in need of additional adjustment, because no change in the Ku-band Cal Table had been made from the start of Side B until cycle 259.

The Table G-1 data, as plotted in Figure 3-22 through Figure 3-24, represents our current best guess at the Cal Table corrections; as there will be no more TOPEX data, Table G-1 is our recommended set of Cal Table corrections for anyone wanting to correct the entire set of TOPEX sigma0 data.

3.3 Side B Point Target Response

Changes in the TOPEX Side A altimeter became apparent around the middle of 1998. The first symptoms of the changes were an increase in the altimeter's SWH estimates and an increase in the range rms. Subsequent investigation revealed apparent changes in the altimeter's point target response (PTR); these changes were shown by the waveform data in the altimeter's Calibration Mode 1 (CAL1). The Side A PTR changes were the main reason that the altimeter was switched to its Side B in February 1999 near the start of cycle 236.

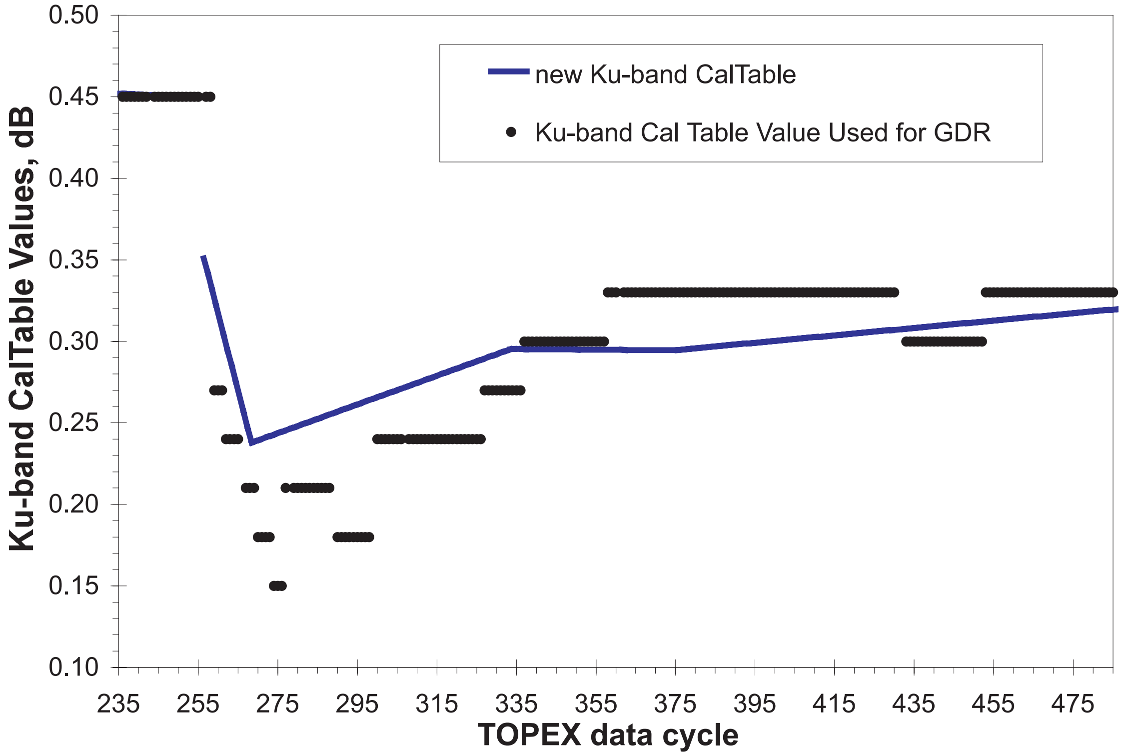

Figure 3-22 Ku-band Side B Old and New CalTable Values vs. Cycle

The normal TOPEX CAL1 was executed at least twice daily throughout the entire TOPEX operation. In CAL1 a portion of the transmitted signal was fed back into the altimeter receiver through a special calibration attenuator and the altimeter tracked this transmitted signal using a special tracking algorithm. During the preflight testing a special calibration mode sweep test (the CalSweep) was developed in which the altimeter did not automatically track the PTR; instead the AGC level was frozen at a preset level and the altimeter's fine-height word was incremented through its entire range (equivalent to 8 waveform sample positions). The CalSweep waveforms could be processed to give a "fine-grained" look at the PTR. After the Side A overestimates of SWH became apparent, a software patch was uploaded to TOPEX to allow the CalSweep to be executed on-orbit. The CalSweep was executed approximately monthly from mid-1998 through the end of the Side A operation. The TOPEX Radar Altimeter Engineering Assessment Update - From Launch to Turn-Off of Side A on February 10, 1999 (NASA TM-212236, Volume 12, August 1999) contains a more detailed discussion of the Side A PTR observation by CAL1 and CalSweep, and the consequences of the Side A PTR change.

The CalSweep continued to be executed once every three data cycles (about once a month) for the entire time of Side B operation until the CAL1 delta range toggling appeared early in cycle 364. From that time onward, the CalSweep was executed once per data cycle. The increase in number of CalSweeps was an attempt to find other TOPEX changes which could be correlated with the onset of the CAL1 delta range

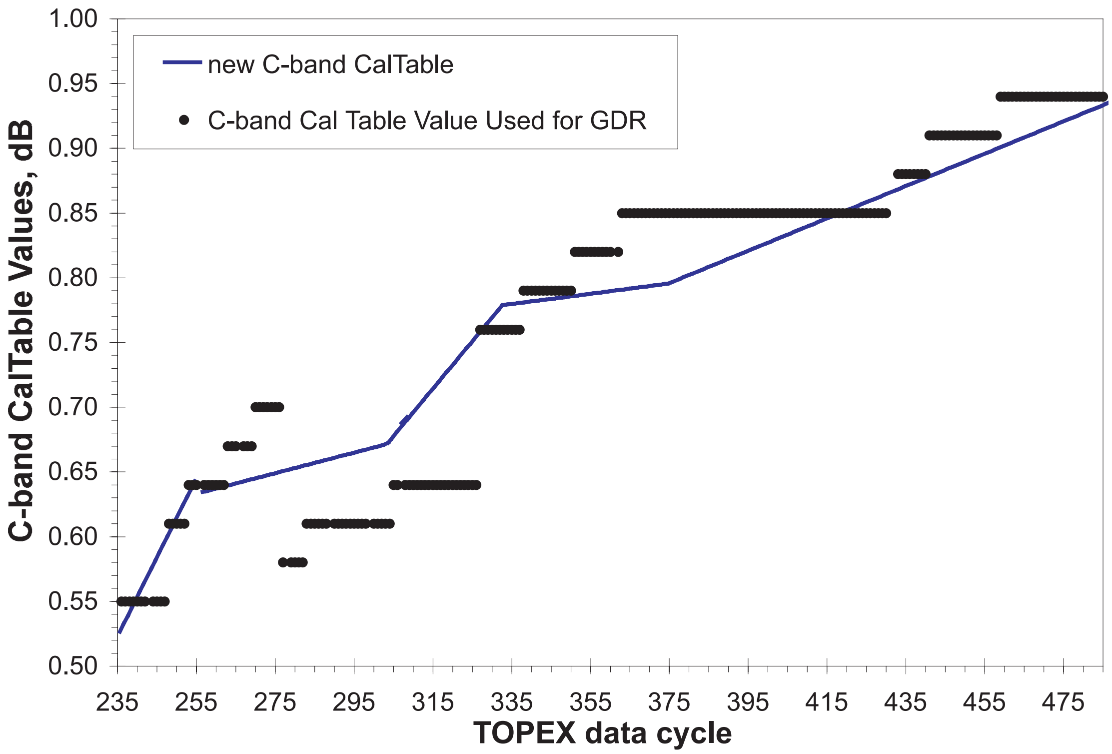

Figure 3-23 C-Band Side B Old and New CalTable Values vs. Cycle

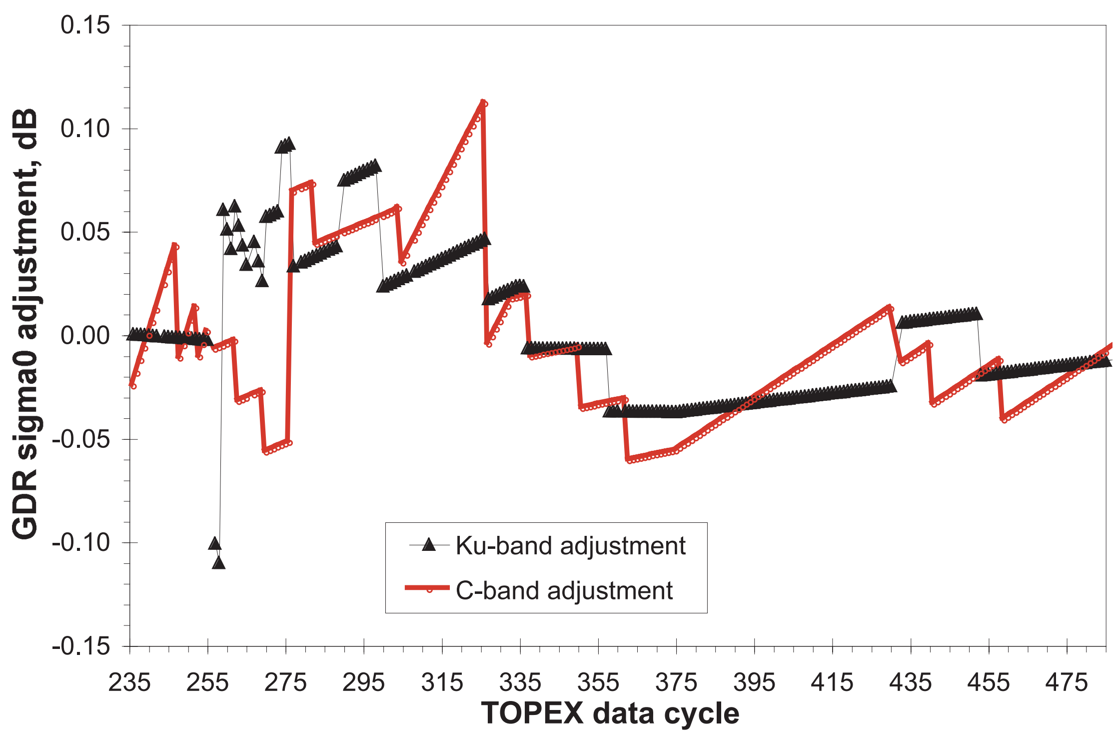

Figure 3-24 TOPEX Side B Sigma0 Adjustments vs. Cycle
(values to add to GDR sigma0, to replace "old" by "new" CalTable)

toggling. Although we have found nothing in the CalSweep results that could be associated with the change in the CAL1 delta ranges, the CalSweeps continued to be executed once per cycle.

Figure 3-25 shows the comparison of an early Side B Ku-band CalSweep (1999 day

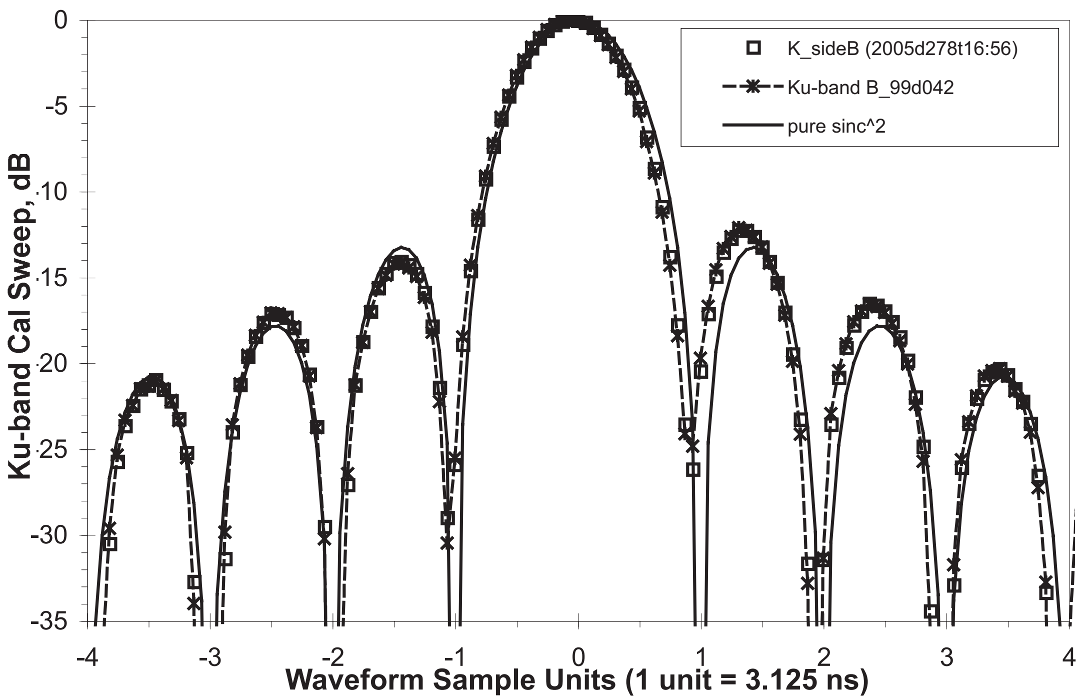

Figure 3-25 TOPEX Side B Ku-band Cal Sweep 2005 Day 278

042) with the last Ku-band CalSweep of year 2005 (2005 day 278, in cycle 481). Figure 3-26 shows the same comparison for the Side B C-band altimeter. As a reference, the theoretical model for the PTR is shown by the pure sinc2 function plotted in Figure 3-25 and Figure 3-26. Only the central lobe and the first five sidelobes are shown in these figures. To within the accuracy and repeatability of the CalSweep, there has been practically no perceptible change in the Side B Ku- and C-band CalSweeps from start of Side B through the end of TOPEX data in year 2005. If there had been any changes at all in the Side B CalSweeps, these changes would have been less than the size of the plot symbols in Figure 3-25 and Figure 3-26.

In addition to the CalSweep, further information on the PTR is available from the waveform data in the normal CAL- 1 which is executed about twenty times in each TOPEX repeat cycle. While the CalSweep “paints” the PTR in fine- grained detail, the CAL1 waveform provided only a single sample at about the peak of each of the PTR sidelobes. We maintained a database of waveforms from the first two CAL1 modes in each repeat cycle, and this provided another way of assessing possible PTR changes as a function of cycle. We will use the CAL1 step 5 waveforms for the following dis-

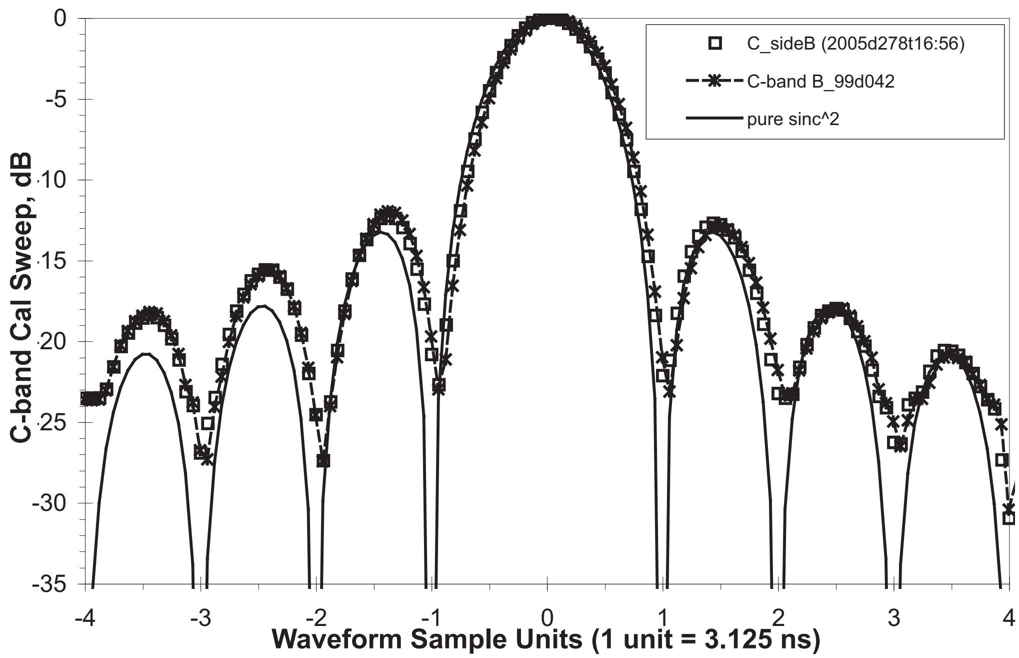

Figure 3-26 TOPEX Side B C-Band Cal Sweep 2005 Day 278

cussion because the AGC level of step 5 is about the same level as in the TOPEX normal over-ocean fine track.

For the TOPEX Side B Ku-band system, Figure 3-27 shows the time history of the first five PTR lobes below the main peak and Figure 3-28 shows the first five lobes above the main peak. These two figures show the Ku-band data from start of Side B operation through the partial cycle 481, and the sidelobe peak values do not appear to exhibit any significant time trend. There could possibly be a hint of small change in the Ku lobes -4 and -5 from cycle 450 onwards, in Figure 3-27, but we don't attach any importance to this. For the Side B C-band system, Figure 3-29 shows the first five PTR lobes below the main peak and Figure 3-30 shows the first five sidelobes above the main peak. While the lower five C-band Side B PTR sidelobes in Figure 3-29 show no significant time trends, there are possible small trends in a couple of the upper five C-band sidelobes in Figure 3-30. The +2 sidelobe shows an increase of about a half dB from start of Side B through partial cycle 381, and the +3 sidelobe shows about an increase for about 3/4 dB over this time. Figure 3-30 may possibly show a step change in these sidelobes at the cycle 256 safehold about 208 days after the start of Side B operation, but we think that these changes are too small to have had any practical consequences in the TOPEX range or SWH estimation.

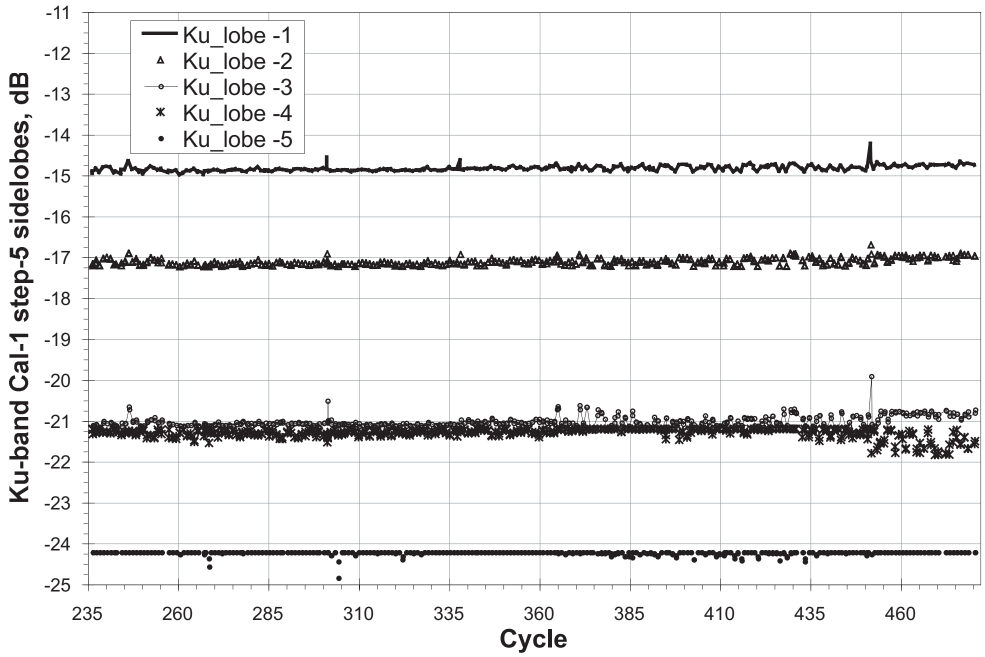

Figure 3-27 Side B Ku CAL1 Lower Sidelobes Relative to Peak Value

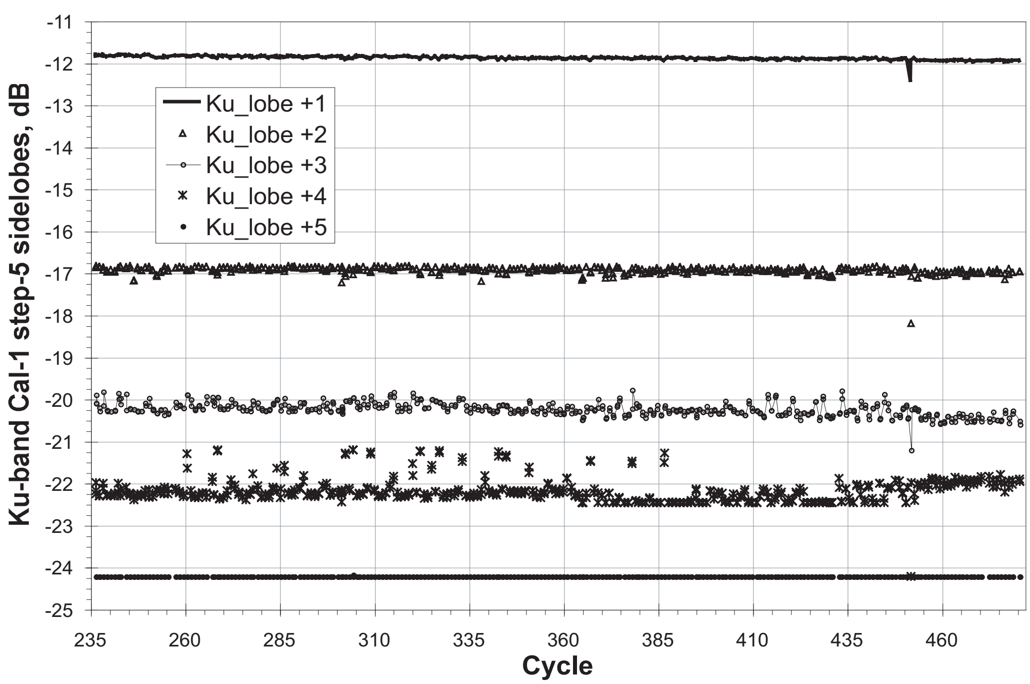

Figure 3-28 Side B Ku CAL1 Higher Sidelobes relative to Peak Value

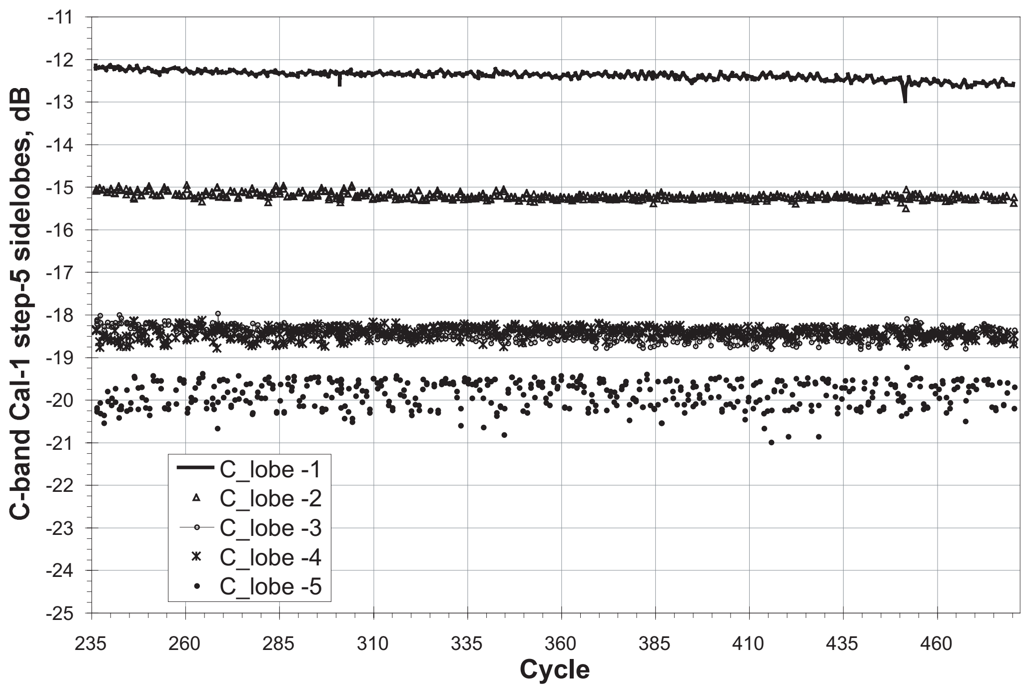

Figure 3-29 Side B C CAL1 Lower Sidelobes relative to Peak Value

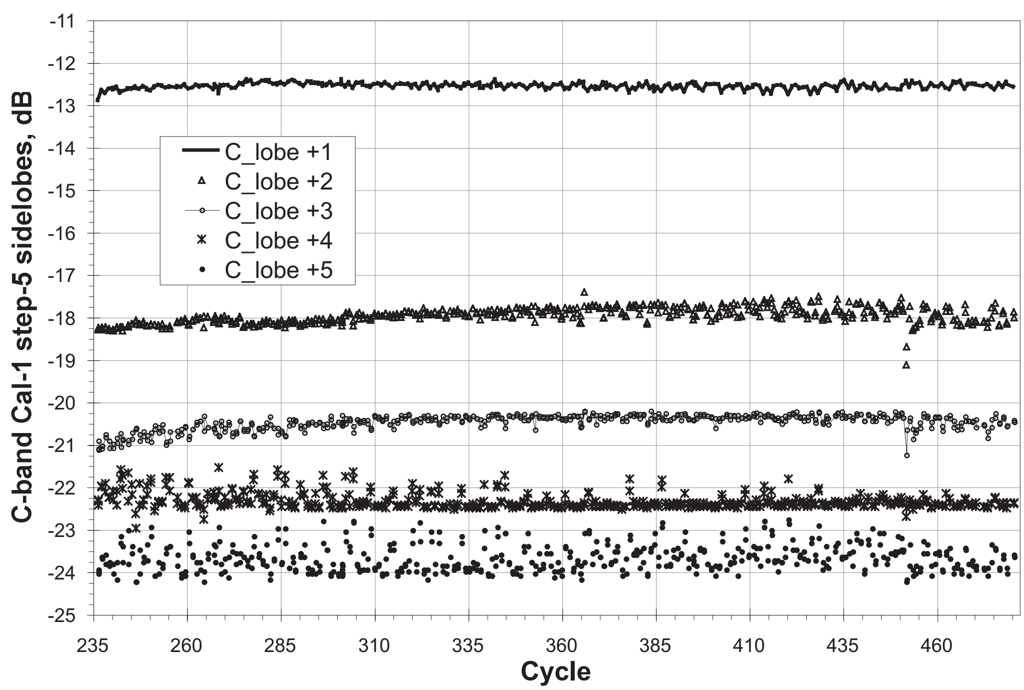

Figure 3-30 Side B C CAL1 Higher Sidelobes relative to Peak Value

Section 4
Ancillary Performance Assessments

4.1 Range Measurement Noise

The TOPEX altimeter white noise levels were evaluated using a technique, based on high-pass filtering of 1-Hz sea surface height time series, as described in Section 4.2 of the *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2001*, June 2001. This filtering technique isolated the portion of the spectrum that should be dominated by the white noise floor and interpreted as the contribution of the instrument noise. It was simpler to use than repeat track-sampling comparisons, allowed the analysis of much larger amounts of data, and in this manner, was more efficient in estimating the noise. Monitoring of the noise level of the altimeter over time would help to detect hardware changes. Range measurement noise versus SWH are provided in Appendix B.

The TOPEX altimeter noise level was estimated to be about 1.8 cm for a 2 m SWH. Several parameters from Table B-1 are shown in Figure 4-1 and are good indicators of the consistent and excellent performance of Side B. The noise level estimates provided in Table B-1 in Appendix B demonstrate stability from cycle-to-cycle with the basic linear dependence of the noise level upon significant waveheight (SWH).

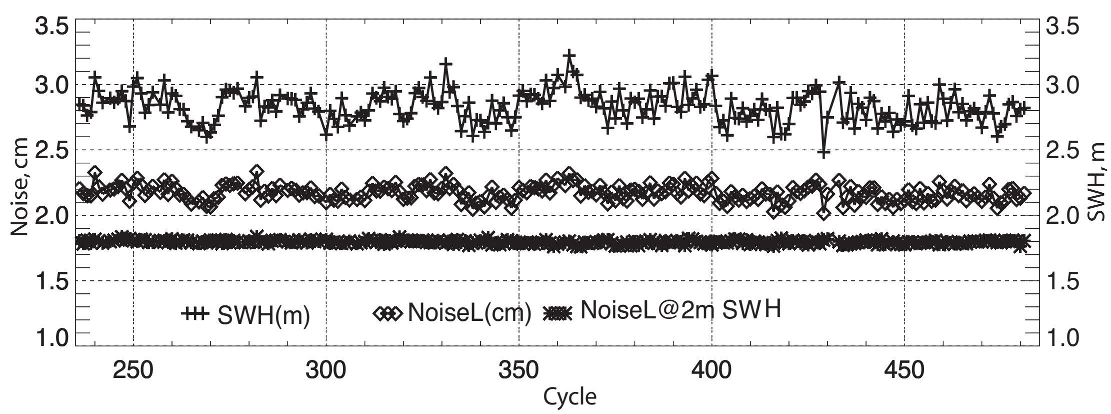

Figure 4-1 Plot of Selected Statistical Indicators from Table B-1

4.2 Differencing as a Continuing System Health Monitor

An ancillary method of performance analysis we used was the differencing of parameters. The method proved to be effective in verifying system stability.

Figure 4-2 "Cycle-Average SWH Delta in Meters" plots cycle averages of the C-band minus Ku-band significant waveheight difference, from the initial turn-on of Side B to the end-of-mission. The entire range of the delta SWHs was very small, only about 0.01 meters, and we used the delta SWH cycle-averages as a system health monitor rather than as a product having any particular science usefulness. The small variation and trends in delta SWH matched well with the cycle average SWH variations, indicating that the differences were a function of SWH and well within the Ku to C SWH calibrations.

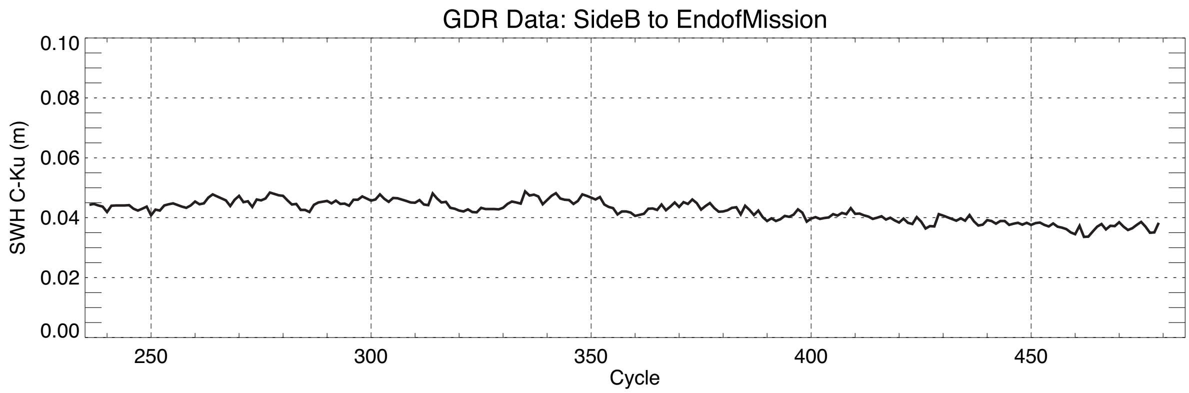

Figure 4-2 Cycle-Average SWH Delta in Meters

Figure 4-3 "Cycle-Average Gate Index Delta" plots cycle averages of the gate index delta, the difference between the secondary (C-band) and the primary (Ku-band) gate index, from Side B turn-on to the end-of-mission. The secondary gate is designated in the plot as SC, and the primary gate is PR. The small difference follows the differences in SWH and not seen as a problem. This figure is again a system health monitor that illustrates the excellent performance stability of Side B.

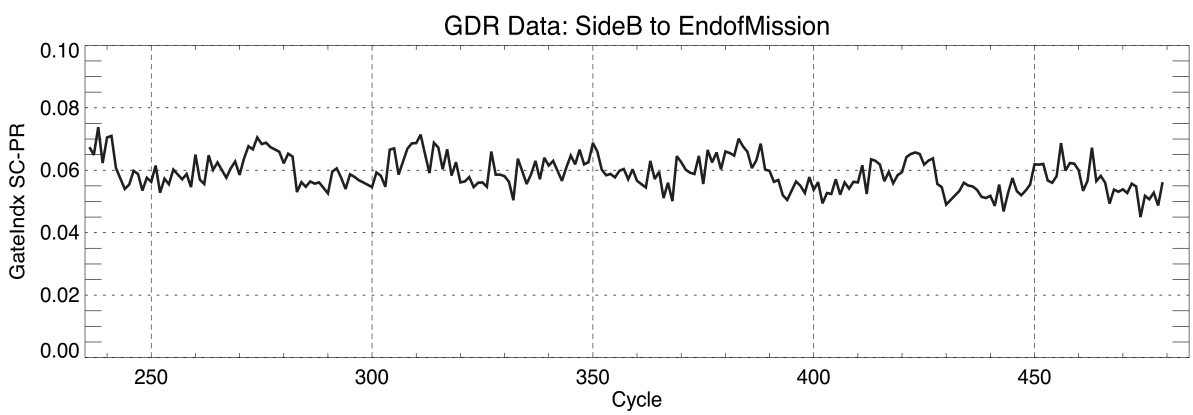

Figure 4-3 Cycle-Average Gate Index Delta

Figure 4-4 "Cycle-Average Sigma0 Delta in dB" plots the sigma0 difference, C-band minus Ku-band, from Side B turn-on to the end-of-mission. This plot provides a quick indication that the sigma0 calibration was maintained to within 0.25 dB. Unlike the previous two figures, however, this figure was not a pure indication of system health, because both the Ku- and the C-band sigma0 calibrations were adjusted during ground processing at the beginning of a number of different cycles throughout the TOPEX mission. For those few groups in the world using the sigma0 difference, relating it to rainfall estimation for instance, we strongly recommend that our TOPEX web site (topex.wff.nasa.gov) be visited. At that web site, we provided a history of the sigma0 calibration changes as well as a possible set of further sigma0 calibration adjustments to be applied to the distributed GDR sigma0 values.

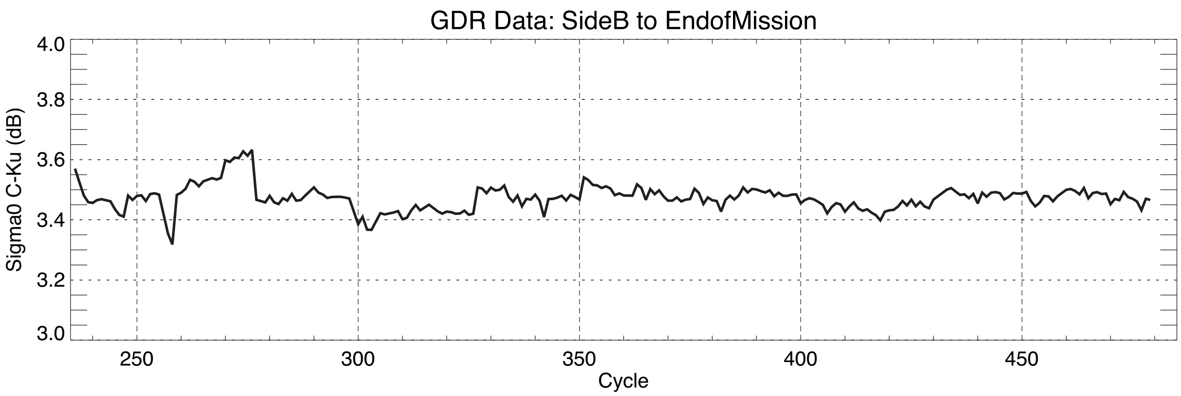

Figure 4-4 Cycle-Average Sigma0 Delta in dB

Some of the relatively abrupt changes in Figure 4-4 are the result of various manual tweaking and adjustment of the sigma0 Cal Table throughout the TOPEX mission. Section 3.2 of this report discusses the TOPEX processing system's Cal Table that adjusts the sigma0 estimates for the effects of possible drifts or trends in the altimeter's power estimation. As discussed in that section, it is possible to reassess the trends based on hindsight and to produce an estimate of a "better guess" set of values that one might wish had been used instead of the actual Cal Table values in the GDR production.

The Side A sigma0 calibration history and our current best estimate of Side A sigma0 adjustments is described in "TOPEX Sigma0 Calibration Table History for All Side A Data", by G.S. Hayne and D.W. Hancock III, July 27, 1999, available at our TOPEX documents web location http://topex.wff.nasa.gov/docs.html. An interim Side B calibration history and set of adjustments is available from "TOPEX Side B Sigma0 Calibration Table Adjustments: March 2002 Update", by G.S. Hayne and D.W. Hancock III, March 8, 2002, also available at http://topex.wff.nasa.gov/docs.html.

A set of cycle-by-cycle adjustments of the sigma0 difference (C- minus Ku-band) was obtained from the Side B calibration history documents just described, and these adjustments were applied to the sigma0 differences (as plotted in Figure 4-4) to produce the result shown in Figure 4-5. Figure 4-5 plots the sigma0 difference (C minus

Ku) based on our best current estimate of the values that should have been in the sigma0 Cal Table. Figure 4-5 appears somewhat smoother than Figure 4-4. With cycle 236 omitted, the entire span of delta Sigma0 plus Cal Table is 3.40 dB-to-3.53 dB, or a +/- 0.065 dB range.

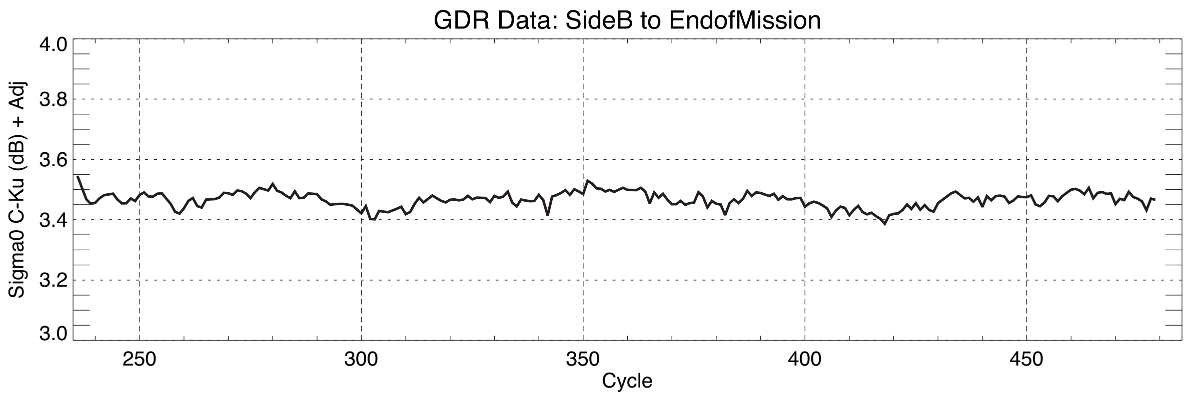

Figure 4-5 Cycle-Average Sigma0 Delta in dB with Cal Table Adjustment

Section 5

TOPEX/POSEIDON Follow-On: JASON-1

JASON-1 is the follow-on to TOPEX/Poseidon. Following its launch on December 7, 2001, JASON-1 was placed in a tandem orbit with TOPEX/Poseidon, in the same orbit and following TOPEX/Poseidon by only 72 seconds. The tandem lasted a total of 210 days (21 cycles), from January 15-August 15, 2002.

The tandem mission was followed by an orbital maneuver to transfer TOPEX/Poseidon to a different orbit, at the same altitude and inclination, but with a ground track midway between the prior ground tracks.

Wallops analyzed the JASON-1 GDR data both during and subsequent to the tandem mission, and compared the JASON-1 performance with TOPEX. Some key results of these comparisons follow.

The JASON-1 data for the cycle summary plots which follow are extracted from the JASON Geophysical Data Record. The method of calculating conventions and editing criteria are per the AVISO and PODAAC Users Handbook, IGDR and GDR Jason Products, Section 3.

5.1 Range Measurement Noise Comparison

The JASON-1 altimeter noise levels were evaluated using a technique similar to the one for the TOPEX altimeter, as described in Section 4.2 of the "TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2001.

The noise level estimates provided in Appendix I were based on 1-minute track segments, and show stable characteristics from cycle-to-cycle with the basic linear dependence of the noise level upon significant wave height (SWH). The altimeter noise level (NL at 2m) for JASON-1 was estimated to be about 2.63 cm and for TOPEX, was estimated to be about 1.79 cm. JASON-1 noise level decreased 0.17 cm since the end of 2003; TOPEX decreased only 0.01 cm. These estimates were the average of all the cycles with each cycle having equal weight. The per-cycle JASON-1 and TOPEX Noise Level estimates are plotted in Figure 5-1, with the noise level at 2m in the lower plot.

Since the start of the evaluation of JASON-1 altimeter noise levels, there were approximately 55% more JASON data points than TOPEX data points. Primarily, the difference in the number of data points was attributed to different editing criteria. Additionally, there may be some small difference attributable to the aging of the TOPEX data tape recorders, resulting in lost data.

It is noted that there is a 0.2 cm systematic decrease in the JASON range measurement noise level beginning at JASON cycle 46. Starting with cycle 46, the reprocessed JASON GDR data were used in the processing of the noise level; prior to cycle 46, the original IGDRs were used for the processing.

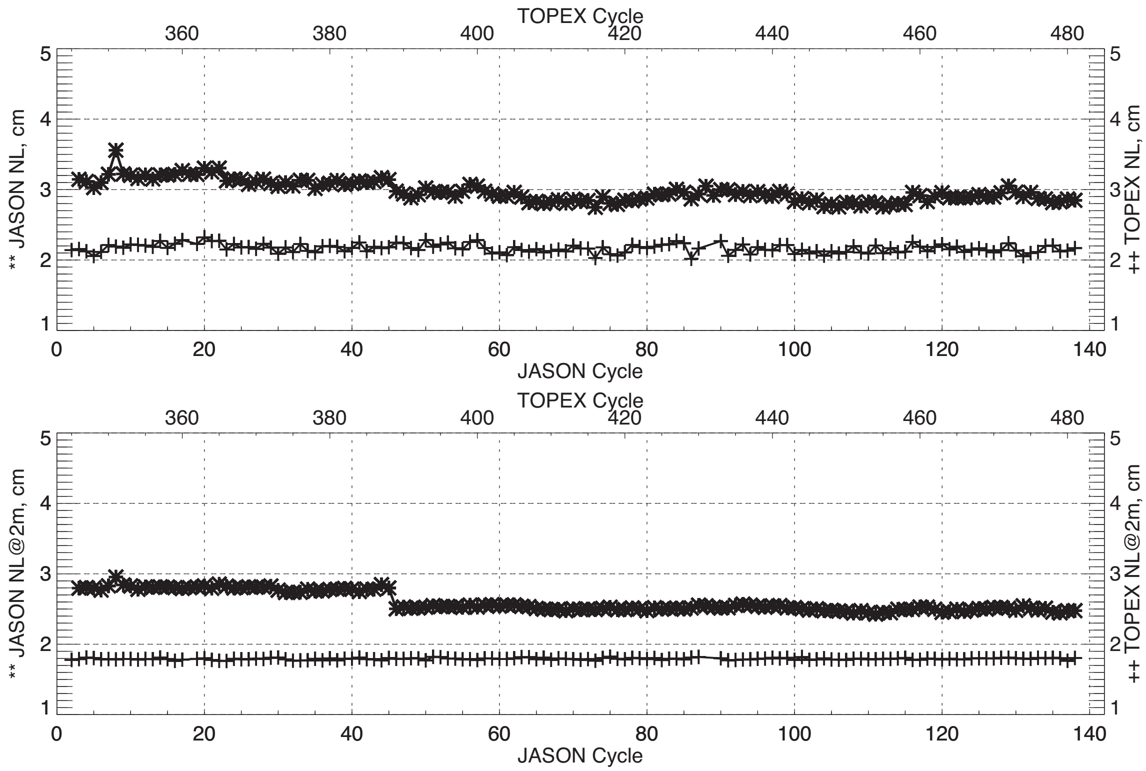

Figure 5-1 JASON/TOPEX Noise Level & Noise Level @ 2m Comparison

5.2 Significant Wave Height (SWH) Comparison

The per-cycle JASON-1 and TOPEX SWH Ku and C estimates, based on 60-second averages, are plotted in Figure 5-2. The JASON-1 SWH Ku average of all the cycles was 2.73 m and the average SWH Ku for TOPEX was 2.79 m, a difference of 0.06 m. The JASON-1 SWH C averages of all the cycles was 2.74 m and the average SWH C for TOPEX was 2.83 m, a difference of 0.09 m. The last few cycle mean differences changed but we believe this to be that TOPEX SWH was lower because of the data lost in the South Pacific, due to tape recorder failures. Figure 5-3 depicts the per-cycle difference between the JASON-1 and TOPEX SWH, for both Ku-band and C-band.

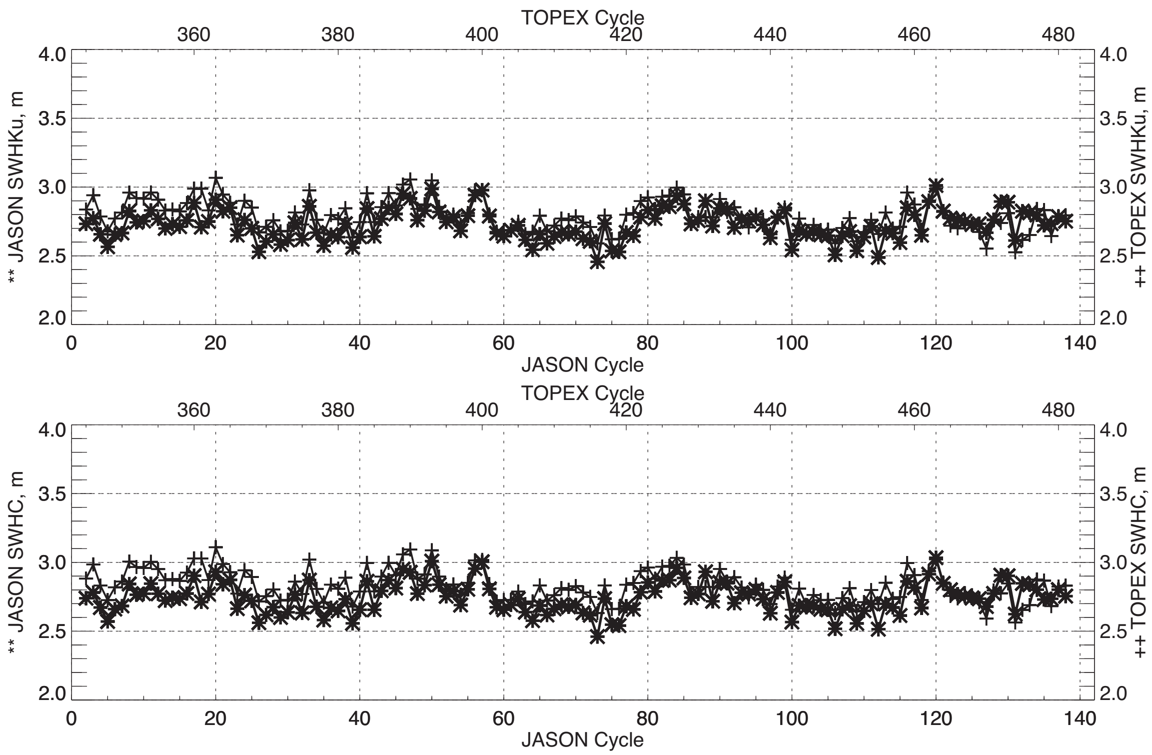

Figure 5-2 JASON/TOPEX Significant Wave Height Comparison

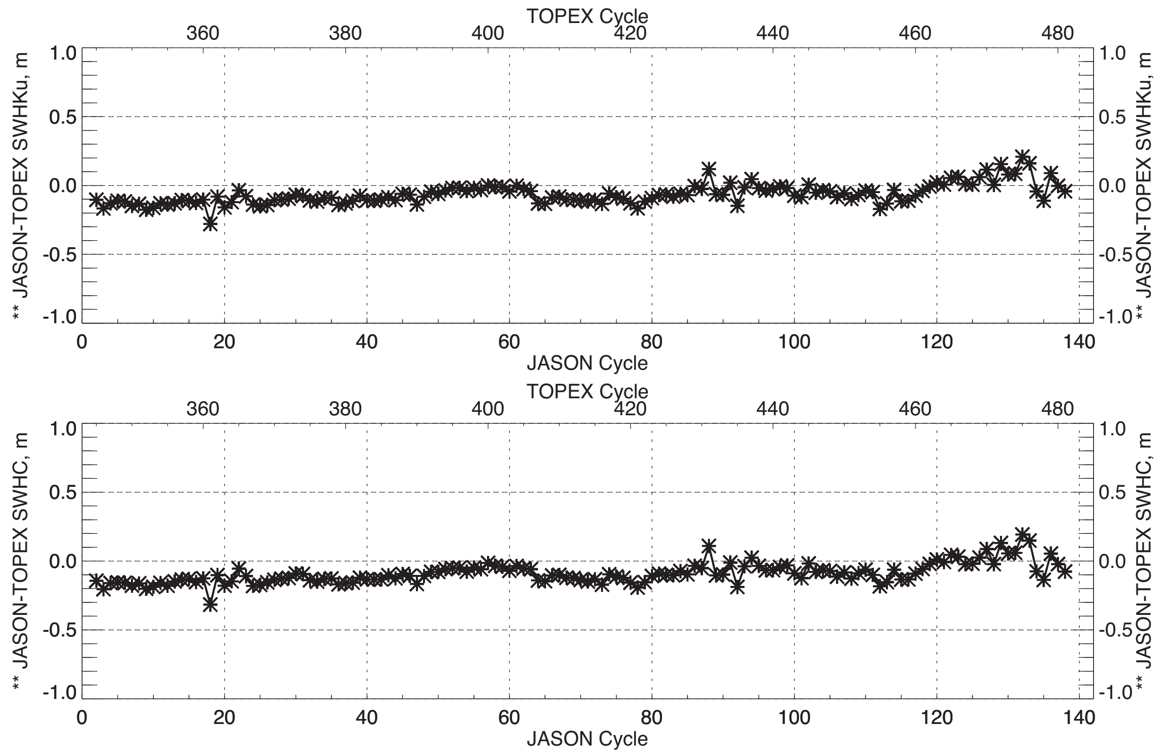

Figure 5-3 JASON/TOPEX SWH Delta in Meters

Figure 5-4 illustrates the per-cycle C-band minus Ku-band difference between the JASON SWH measurements. The corresponding cycle-average SWH delta for TOPEX is shown in Figure 4-2 on page 4-2.

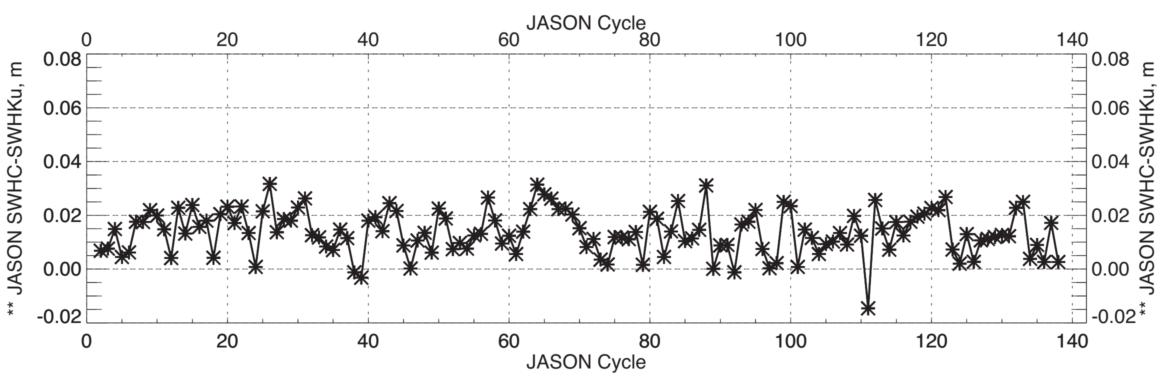

Figure 5-4 JASON Cycle-Average SWH Delta in Meters

5.3 Sigma Naught Comparison

The per-cycle JASON-1 and TOPEX Ku-band Sigma0 estimates, based on 60-second averages, are plotted in Figure 5-5. The JASON-1 Ku Sigma0 average was 13.60 dB, and the Ku Sigma0 average for TOPEX was 11.17 dB, a difference of 2.43 dB. The C Sigma0 average for JASON was 15.32 dB, and the C Sigma0 average for TOPEX was 14.65 dB, a difference of 0.67 dB, and again the JASON-1 value was larger. Figure 5-6 shows the per-cycle difference between the JASON-1 and TOPEX sigma0, for both Ku-band and C-band.

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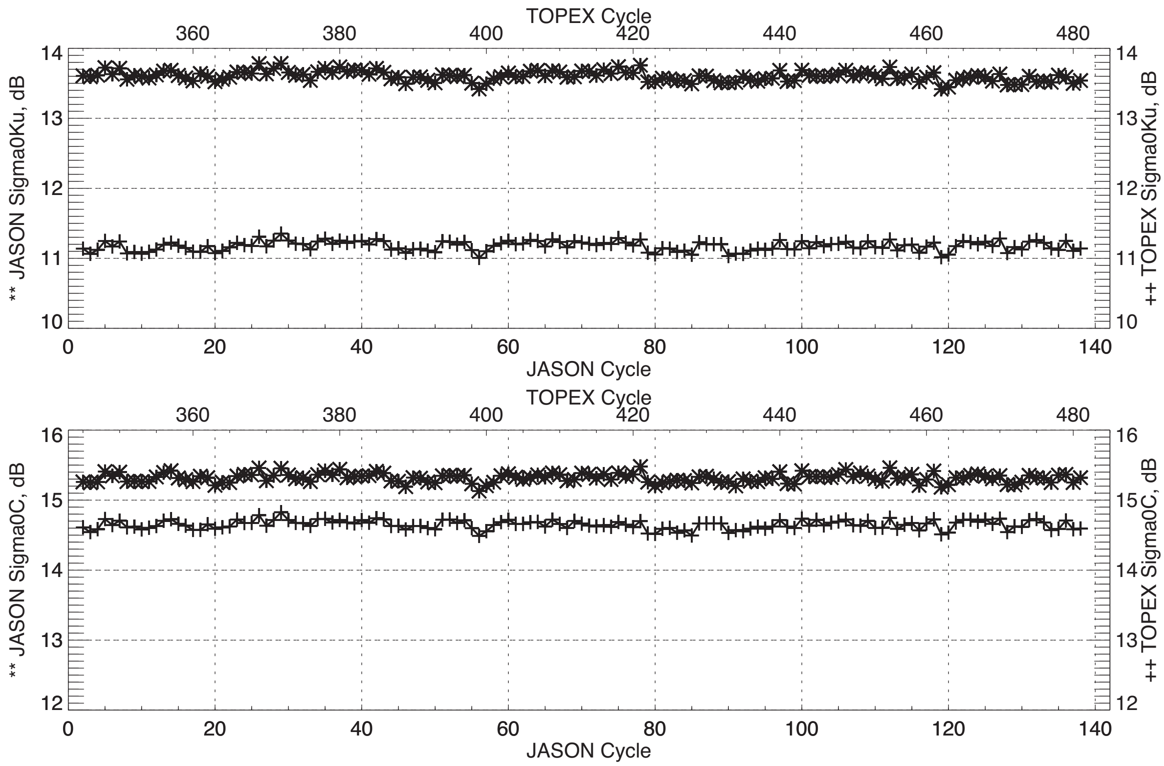

Figure 5-5 JASON/TOPEX Sigma Naught Comparison

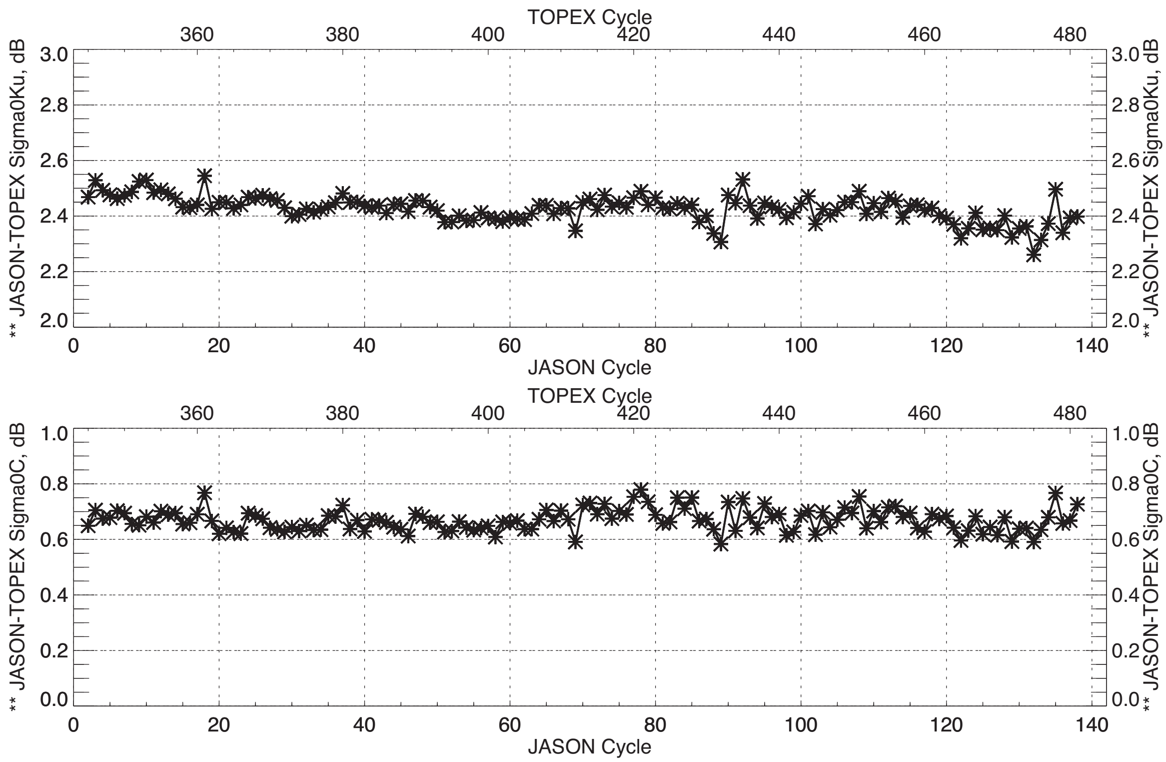

Figure 5-6 JASON/TOPEX Sigma0 Delta in dB

Figure 5-7 illustrates the per-cycle C-band minus Ku-band difference between the JASON Sigma0 measurements. The corresponding cycle-average Sigma0 delta for TOPEX is shown in Figure 4-4 on page 4-3, and in Figure 4-5, page 4-4 that shows the Sigma0 difference based on the best current estimates of Sigma 0 Cal Table. The JASON difference has the appearance of a small calibration drift between Ku and C-band.

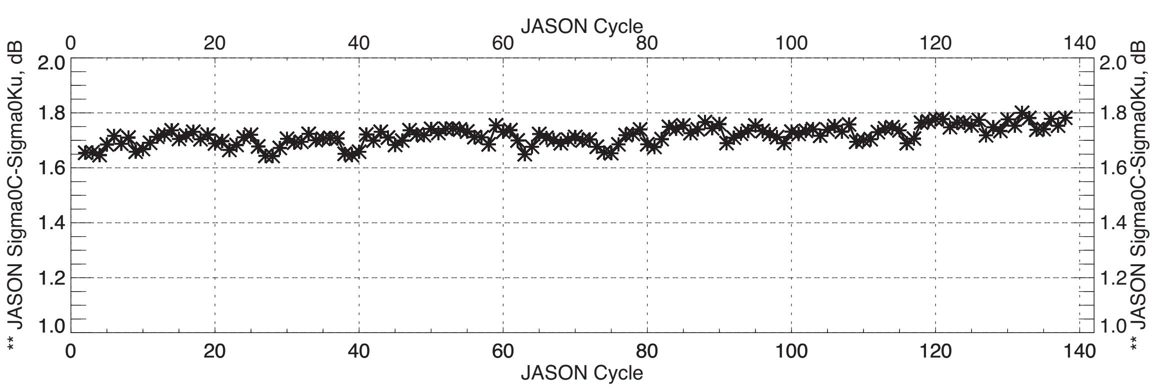

Figure 5-7 JASON Cycle-Average Sigma0 Delta in dB

5.4 Sigma Naught vs. Significant Wave Height Comparison

The upper plot in Figure 5-8 depicts TOPEX and JASON-1 Sigma0 for Ku-band vs. the corresponding SWH. The lower plot in Figure 5-8 is similar except that it is for C-band. In both plots, the slopes of the relationship of Sigma0 to SWH are nearly identical. The Sigma0 and SWH biases between the two altimeter systems are readily apparent.

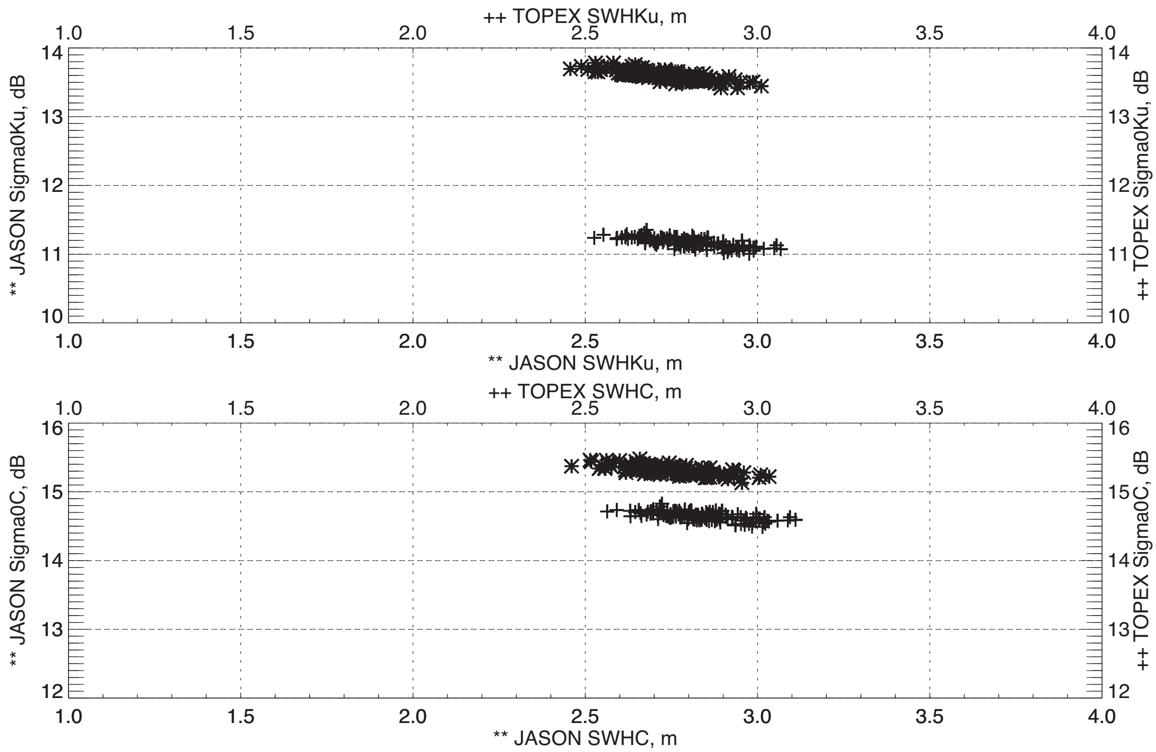

Figure 5-8 JASON/TOPEX Sigma0 vs. SWH Comparison

5.5 Sea Level Anomaly Comparison

Sea level anomalies, also called residual sea surface heights, have been calculated for both altimeters by subtracting previously-unmodeled tides, mean sea surface, and barometric effects from the GDR-provided sea surface heights. The JASON-1 sea level anomaly average of all the cycles is 0.18 meters, and the average residual sea surface height for TOPEX is 0.01 meters.The per-cycle JASON-1 and TOPEX estimates, based on 60-second averages, are plotted in Figure 5-9.

During the 21-cycles of tandem operations, the JASON-1 sea level anomalies were approximately 17.4 cm higher than TOPEX. Subsequent to the tandem operations, the differences decreased slightly, to about 16.4 cm. The per-cycle JASON-minus-TOPEX sea surface height difference are plotted in Figure 5-10. The observed ~2 cm rise in the delta SSH began with JASON-1 cycle 106 at the end of 2004.

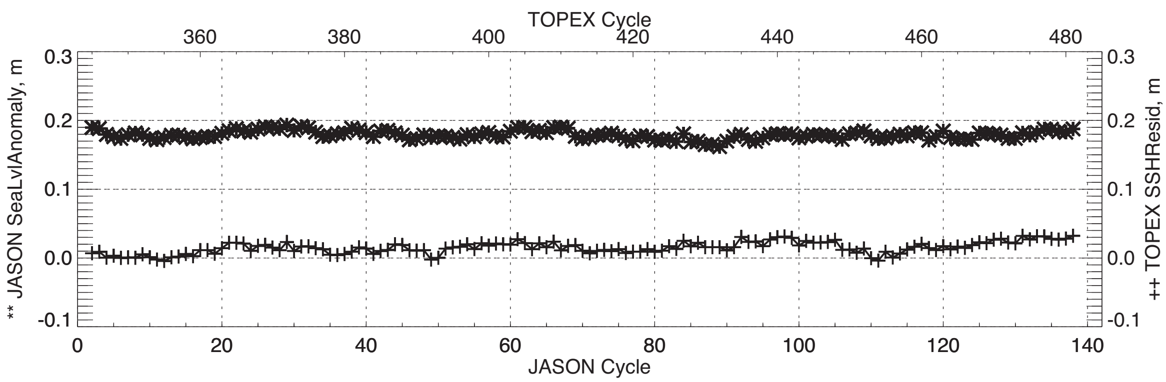

Figure 5-9 JASON-SLA/TOPEX-SSHRES Comparison

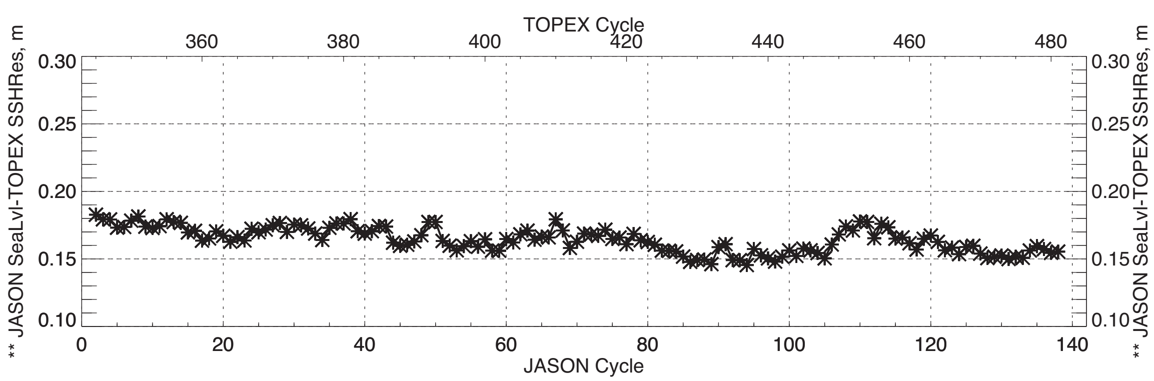

Figure 5-10 JASON-SLA/TOPEX-SSHRES Delta in Meters

Section 6

TOPEX Side A End-of-Mission Turn-On

6.1 Side A Performance

The TOPEX Side A altimeter was turned on for an engineering test in November 2005. This test showed that the Ku- band system performance was nearly identical to the last Side A data collected in February 1999. The point target response still showed degraded side lobes and may be slightly worse. The C-band system appeared to be functioning; however, the RF output was very low. The C-band power monitor did not give any indication of RF output power so the actual level is assumed to be below its designed detection range. The cal mode data and the cal sweep data indicated a transmit pulse at a very low level. Other than the level of C-Band RF output, all housekeeping monitors were within their expected range. Since both Ku-band and C-band showed the PTR degrade, it is suspected that the problem originates in the common parts of the UCFM for both frequency in the early stages of the UCFM (Upper Converter Frequency Multiplier).

Analysis of the data showed the difference in Side A Ku-band cal mode AGCs for February 1999 and November 2005 for both CAL1 and CAL2 was lower by about 1.5 dB. This could partly be the result of the different temperature environment. For the steps that had some C-band signal, the delta AGC was lower by about 17 dB. The later steps reached a delta noise level of about 1.5 dB less than it was in 1999 including CAL2. This 1.5 dB noise decrease was consistent with an average 10 degree lower temperature based on 1991 pre-launch test data.

The digital unit and all Ku parts were at a lower temperature by about 10 degrees C than in 1999. The C-band MTU was about 14 degrees lower, the GaAs FETS about 18 degrees lower and the C Power converter was about 30 degrees C lower. The lower C-band Power converter temperature indicated that the low C-band RF output was real. Considering the temperature related change, the remaining C- band active signal would be about 15.5 db lower than in 1999. The engineering team believes this indicates the failure of one amplifier stage in the C-band transmitter. All other components and functions appear normal.

Figure 6-1 contains the CalSweep result from the last day of Side A operation, labelled K_sideA (1999d040at15:57), the Side A CalSweep just prior to decommissioning, labelled K_sideA(2005d322kt16:41) and the ideal sinc^2 function. Also one of the first Side B CalSweeps which is labelled Ku-band B_99d042 is shown and Side B showed no sign of PTR change over its six years of operation.

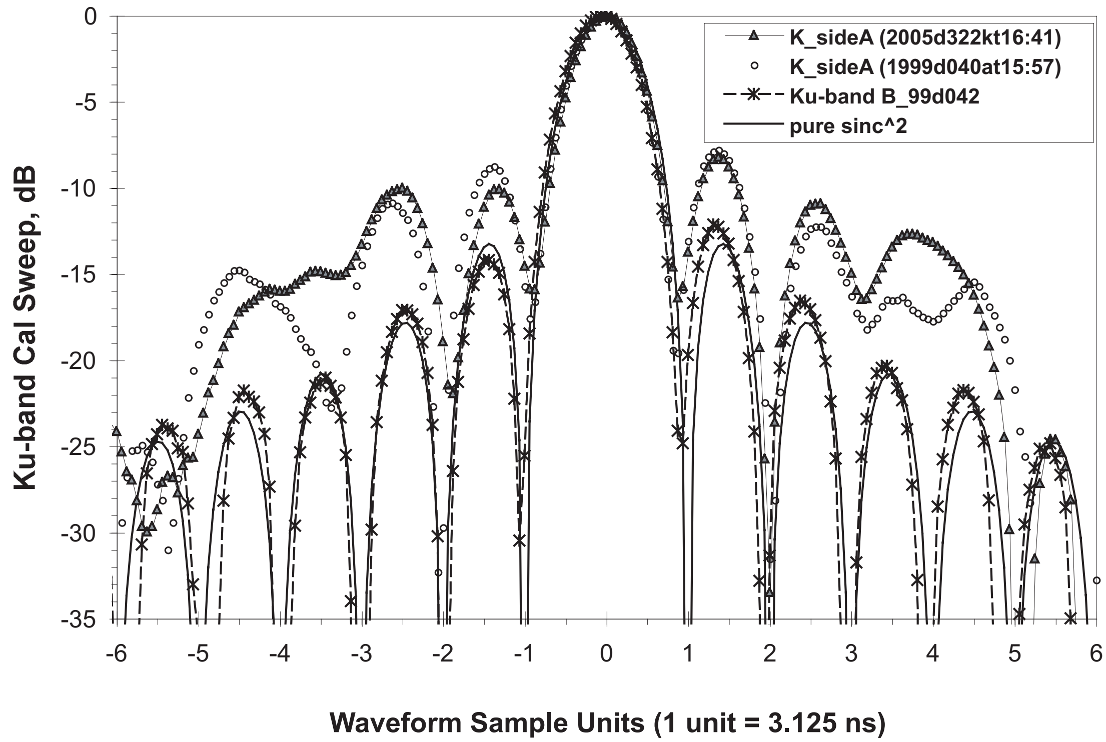

Figure 6-1 TOPEX Side A Ku-Band CalSweep Comparisons

Section 7

Engineering Assessment Synopses

7.1 Side B Performance

Side B of the TOPEX NASA Radar Altimeter (NRA) was turned on, for the first time in space, on February 11, 1999. This followed six-and-a-half years of very successful on-orbit operations by Side A. Side A was turned off due to its Point Target Response having changed slightly over time, affecting measurement consistency. Side B became the operational altimeter; however, Side A could have been turned back on if needed. Side B operated for 6 years and eight months ending on October 9, 2005.

The amount of ground-collected TOPEX NRA data on a daily basis was diminished by the performance degradation of the onboard tape recorders. August 8, 2004, the last of the three onboard tape recorders, TR-C, was removed from service. At the time of its removal, the average hours per day had decreased to 88%. The original science data recovery requirement of 81% was nearly being met solely through the TDRSS real time downloads, whereby the average hours per day had decreased to 79%. The TOPEX data became no longer uniformly global since there were specific geographic areas of data missed because of gaps in the TDRSS coverage. This may affect some science studies.

As global sea surface height data were analyzed scientists found that there was a sub-centimeter distinct bias in the data near the equator. Over the years it has been found that this bias is associated with the change in the sign of the range rate, and empirical corrections were developed by Phil Callahan at JPL to correct the final data products. This characteristic is in both Side A and Side B data but appears to have slightly different correction values. It is possible that these small range errors are an artifact of the way the NRA implemented the fine height tracking interacting with the waveform "sawteeth". The fine tracking and sawteeth are described in the Hayne et al. 1994 JGR paper. The small differences in Side A and Side B could be related to the leakages in Side A.

7.2 Jason Performance

The successful launch of Jason-1 occurred on December 7, 2001, and its performance appears within specification and stable. Many of the techniques we used on the TOPEX NRA are being applied to Jason-1.

The TOPEX spacecraft completed its orbit maneuver transfer to its new orbit on September 16, 2002, during cycle 368. There was no noticed significant changes in instrument performance. Global statistics remained consistent with previous years.

Comparison of Jason data and TOPEX data up to October 9, 2005 showed good agreement in parameters and that both altimeters were stable.

7.3 Side A vs. Side B Performance

As this is the last TOPEX Engineering Assessment report, a few comparisons of the performance of Side A and B will be discussed. It is interesting that each altimeter operated for nearly the same length of time. Side A operated for 235 Cycles and Side B operated for 246 Cycles.

Sometime after 5 years of Side A operation, the Ku height noise in Figure 7-1 showed a change in performance which led to detection that the transmit pulse shape was degrading. This led to the decision to switch operation to Side B after about 6.5 years from launch. Figure 7-2 shows the Ku height performance for Side B. As discussed earlier, Side B did not exhibit the same problem and its small change in the last part of the mission is purely from the different data coverage.

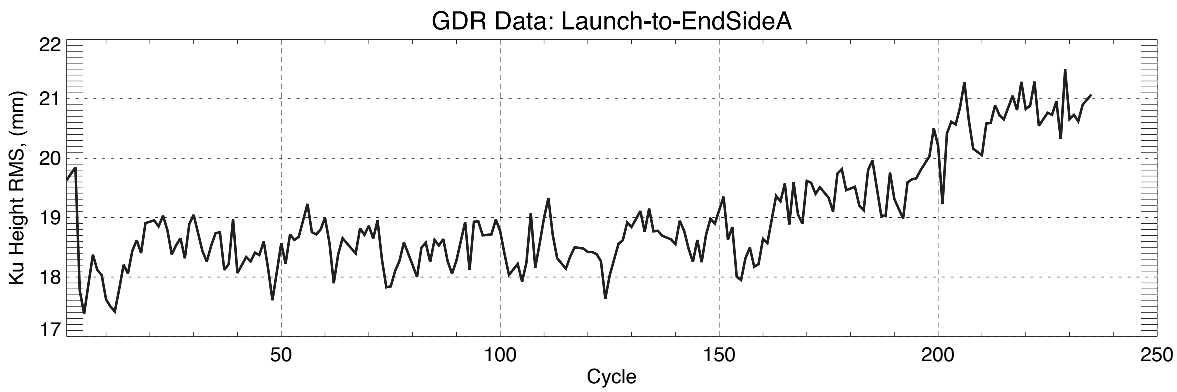

Figure 7-1 Side A, Ku Height RMS

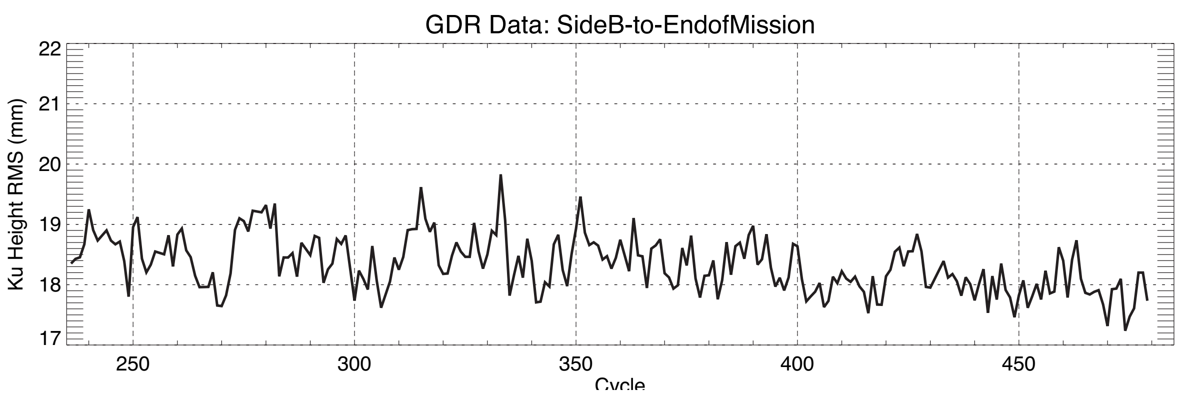

Figure 7-2 Side B, Ku Height RMS

WFF provided calibration corrections for sigma 0 as predictions, and then provided additional post-processing delta corrections (see Section 3.2 of this report for further discussion of the sigma0 corrections). Figure 7-3 and Figure 7-4 for Ku-band, and Figure 7-5 and Figure 7-6 for C-band show the cycle average sigma0 after final correction. The remaining variations are assumed to be related to the cycle average waveheight (SWH) variations.

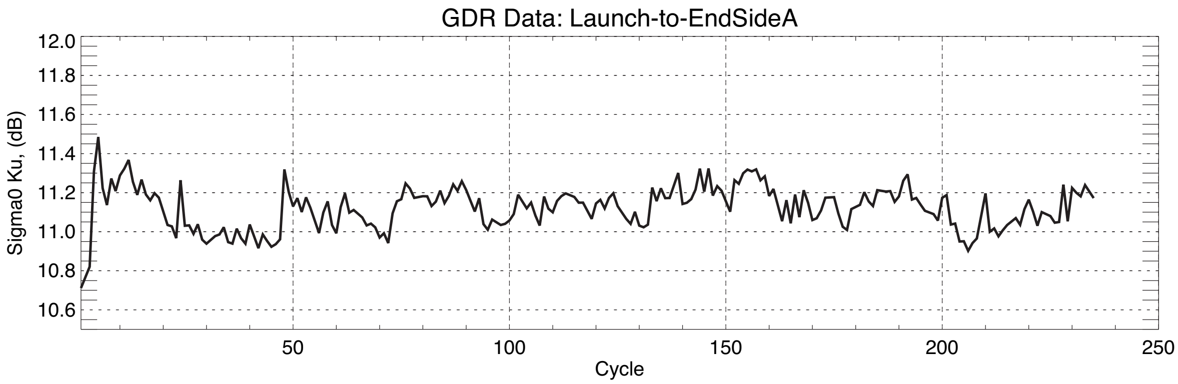

Figure 7-3 Side A, Sigma0 Ku

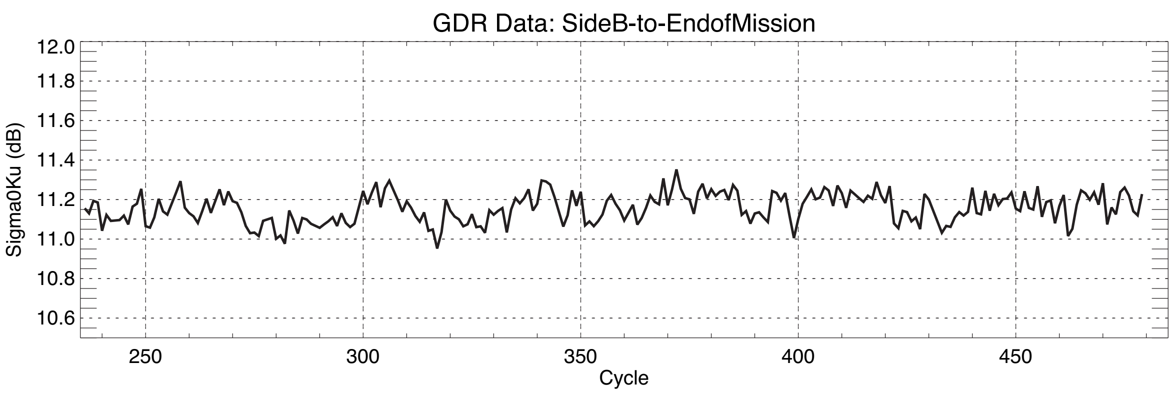

Figure 7-4 Side B, Sigma0 Ku

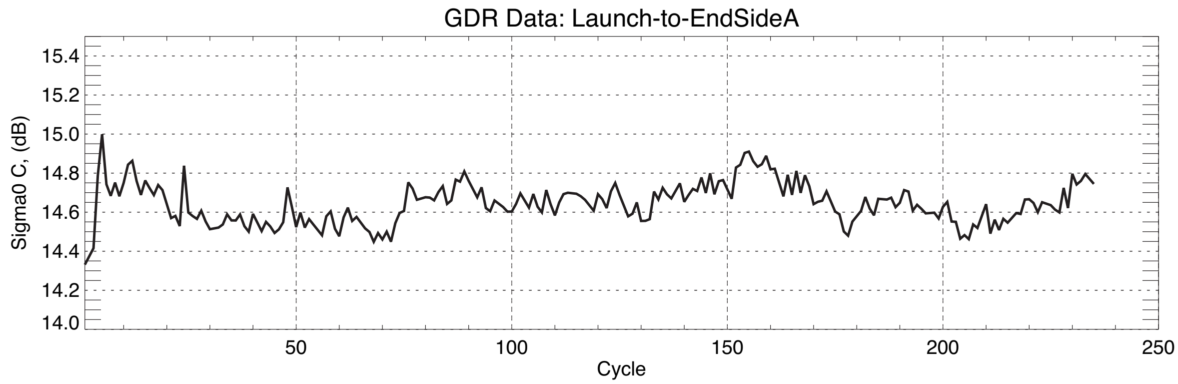

Figure 7-5 Side A, Sigma0 C

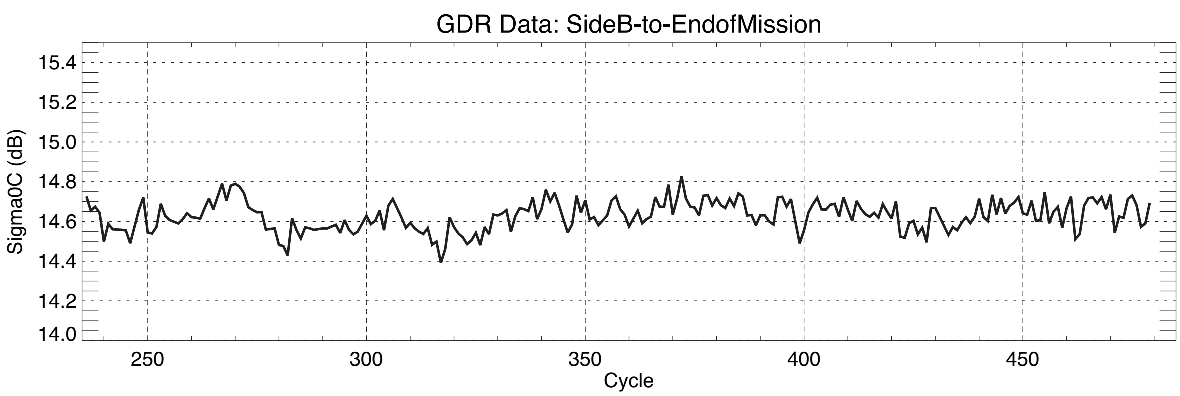

Figure 7-6 Side B, Sigma0 C

For all thirteen years of operation, the altimeters remained in a very stable temperature environment. There were minor orbit temperature variations and a few degrees of orbit seasonal variations. Figure 7-7 and Figure 7-8 depict the AGC receiver sector temperatures over the operation lifetime of Side A and Side B.

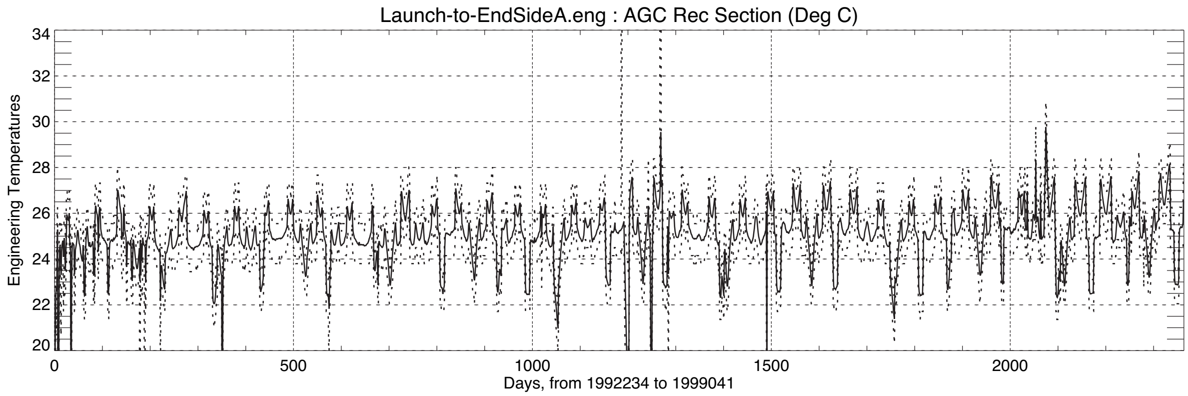

Figure 7-7 Side A, AGC Rec Section

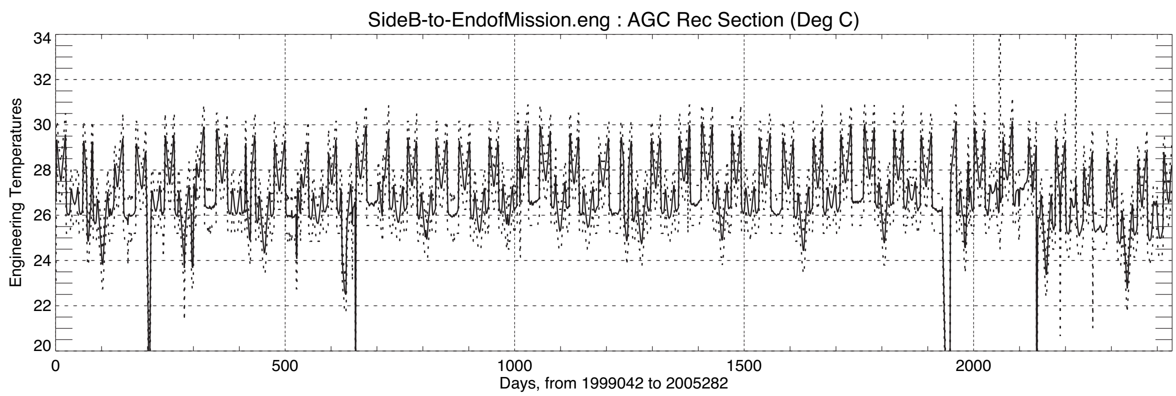

Figure 7-8 Side B, AGC Rec Section

The only abnormal temperature control was for the Side B digital chirp generator (DCG). It was attributed to failure in a heat sink. Figure 7-9 and Figure 7-10 show Side A and Side B performance. Side B initially exhibited a small rise each year but then stabilized. The larger dips in these temperatures were during SSALT operation or spacecraft events.

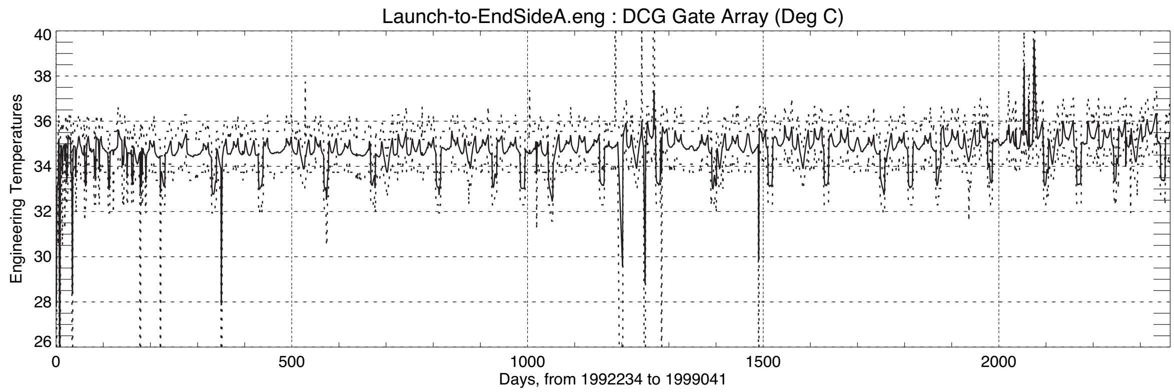

Figure 7-9 Side A, DCG Gate Array

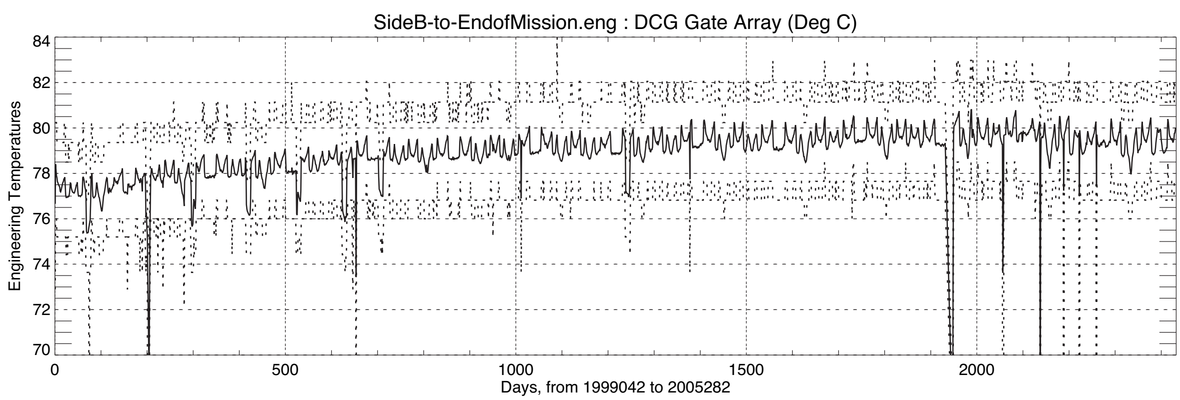

Figure 7-10 Side B, DCG Gate Array

The altimeter low volt power supplies provided remarkable stable performance throughout the life of TOPEX. Figure 7-11 and Figure 7-12 illustrate the regulated 5 volt output. This figure is typical of all voltages and currents.

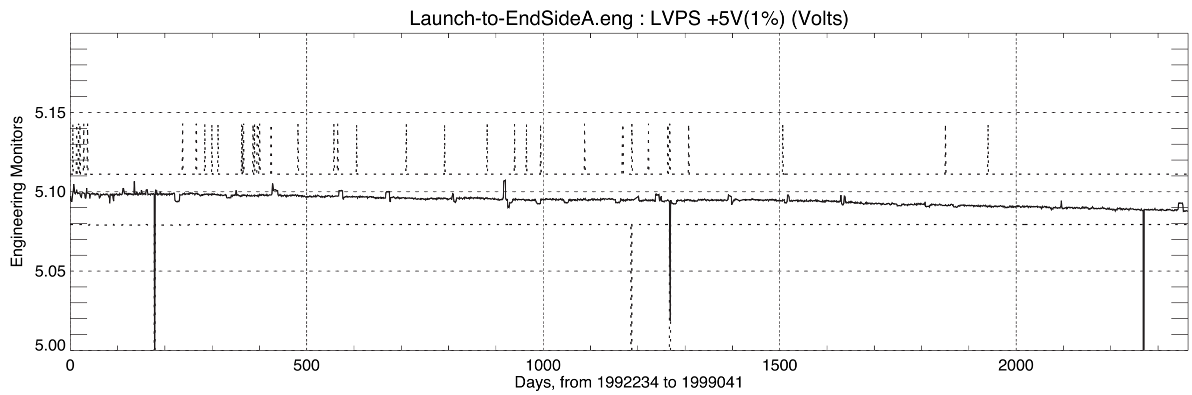

Figure 7-11 Side A, LVPS +5V

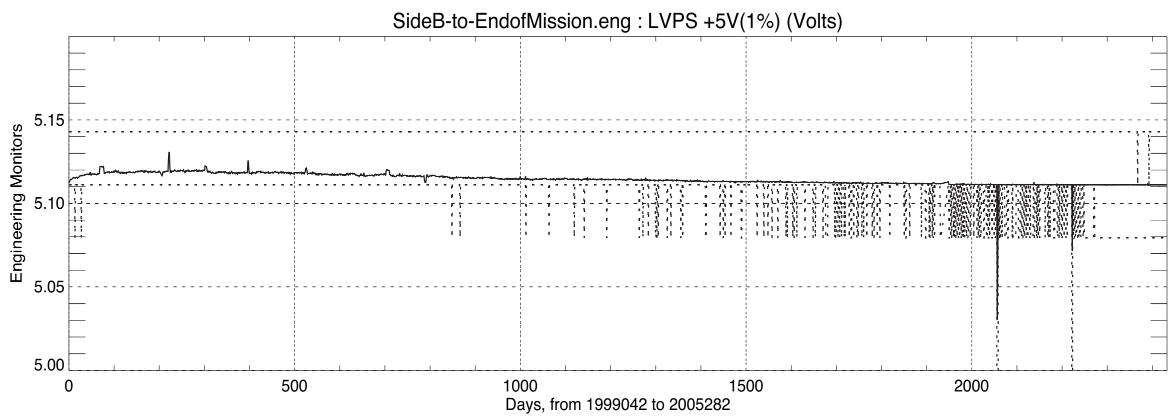

Figure 7-12 Side B, LVPS +5V

Both C-band solid state amplifiers (CSSA) showed minor power lost over their years of operation. The expected performance was to have a faster initial decay rate with less decay with time. Both Side A and Side B exhibited this characteristic. The performance over time of each showed a slightly different characteristic but both were considered to be well within its engineering design expectation. Figure 7-13 and Figure 7-14 summarize the CSSA performance. The C-band transmit power was consistent with these currents (see Figure 7-15 and Figure 7-16).

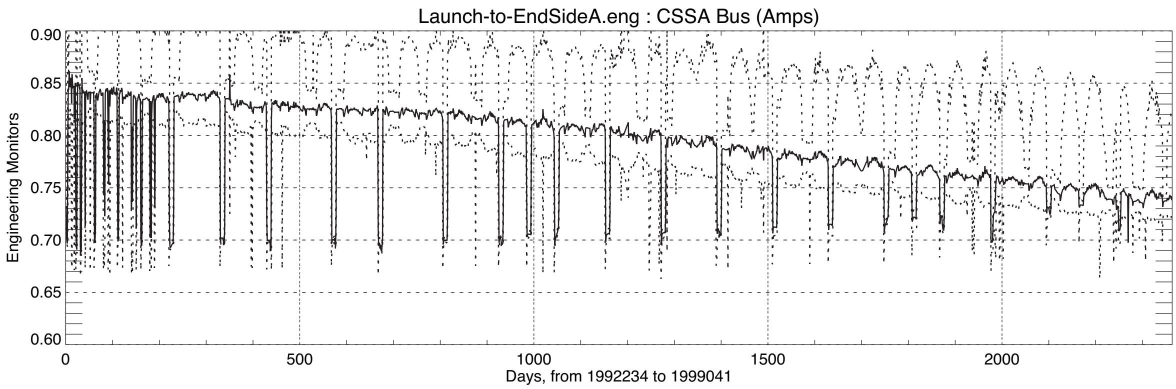

Figure 7-13 Side A, CSSA Bus

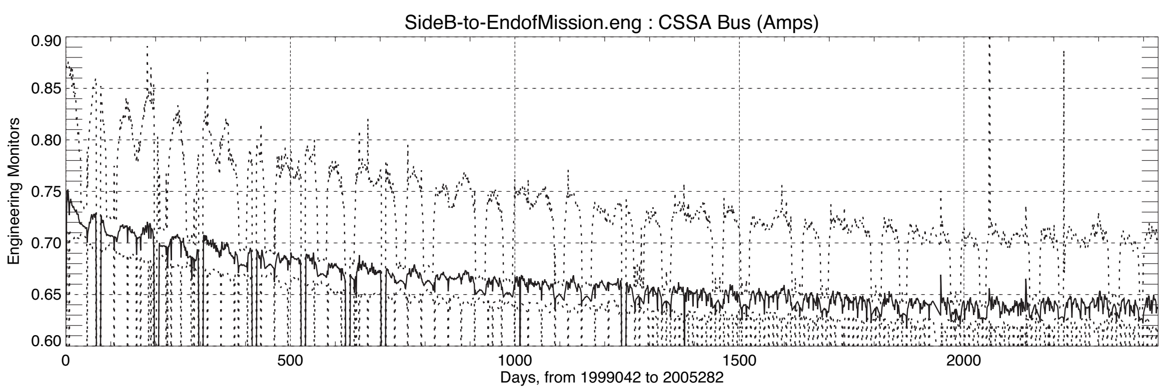

Figure 7-14 Side B, CSSA Bus

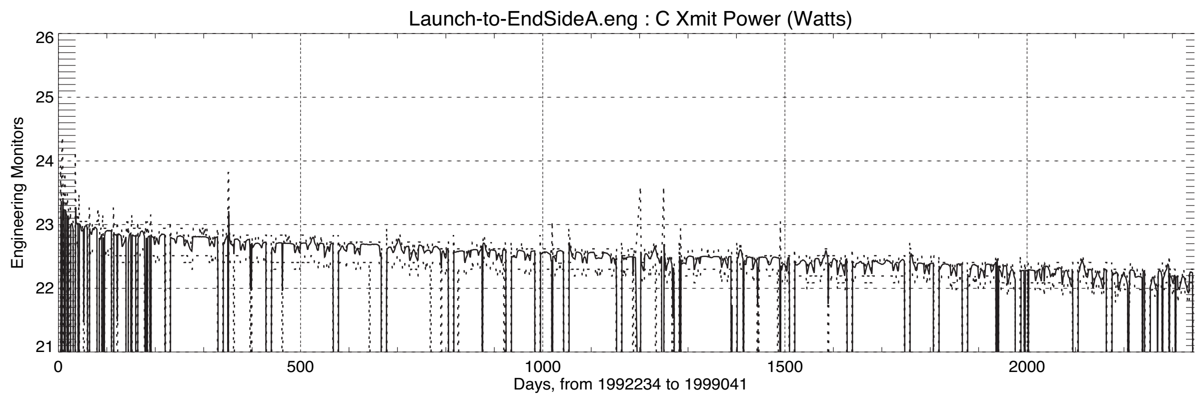

Figure 7-15 Side A, C Xmit Power

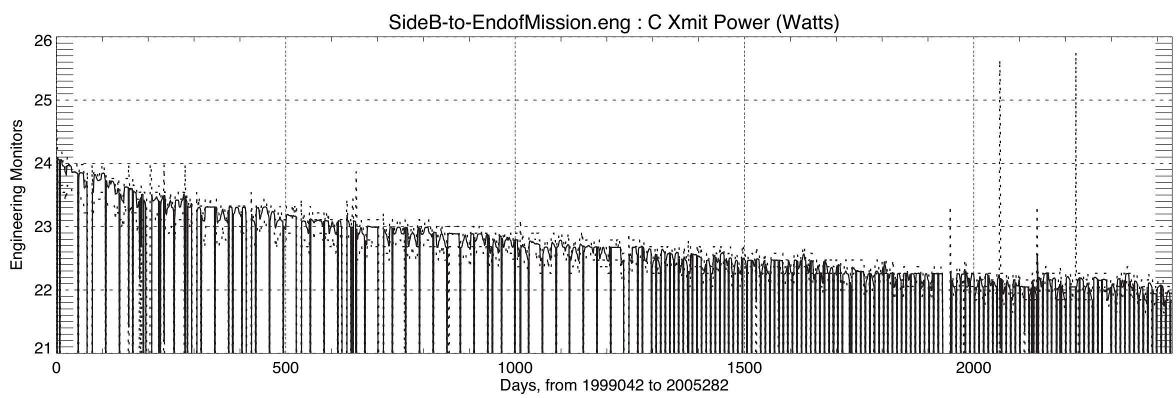

Figure 7-16 Side B, C Xmit Power

The heart of the NASA altimeters was its Ku-band Traveling Wave Tube (TWT) amplifiers. These performed excellently. Both Side A and Side B showed no sign of degrade after each operated over 6 years. Figure 7-17 and Figure 7-18 show the Ku Transmit Power for Side A and Side B.

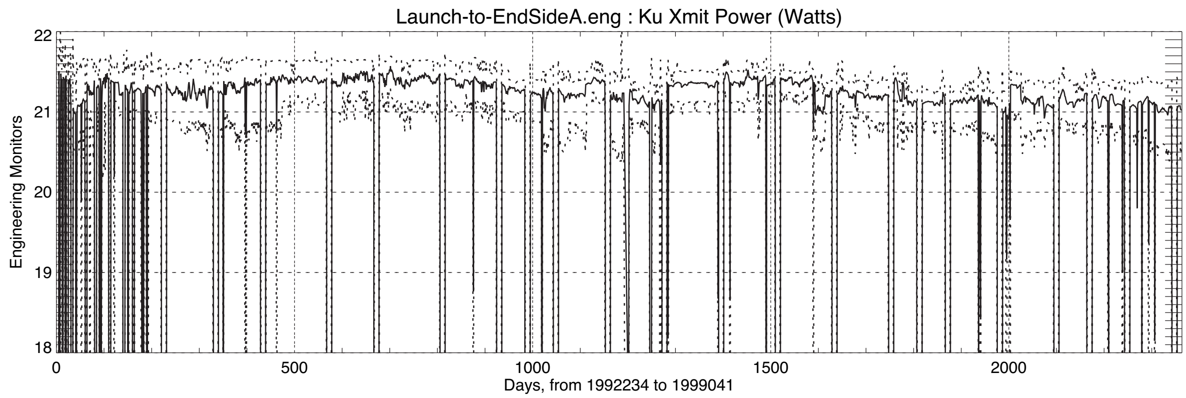

Figure 7-17 Side A, Ku Xmit Power

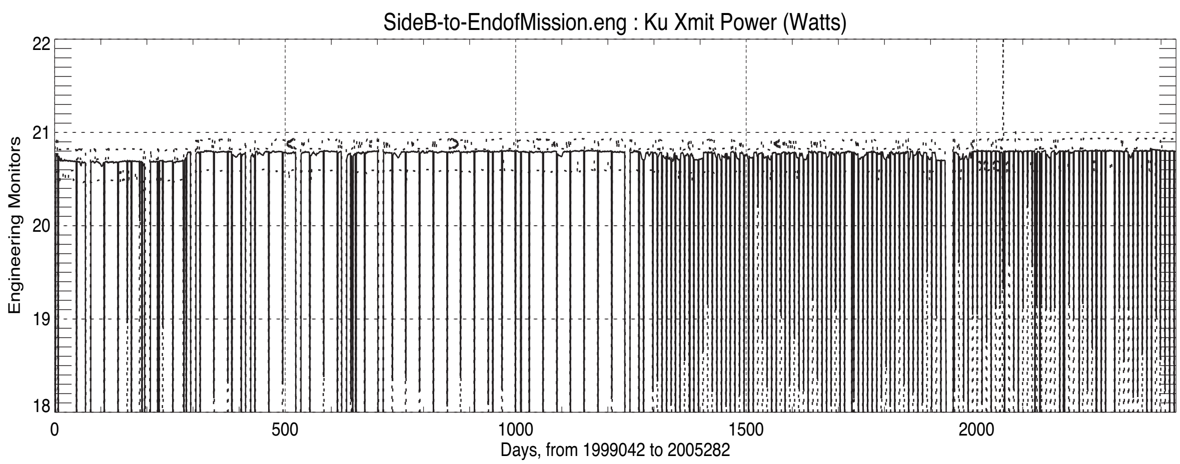

Figure 7-18 Side B, Ku Xmit Power

The transmit and receiver sections of both Side A and Side B performed very well. The engineering data included both Ku- and C-band transmitted power monitors to track changes in the altimeter transmitted powers, and the Calibration Mode was intended to monitor changes in the receiver gains for both the Ku- and the C-band. As shown in Figure 7-18 "Side B, Ku Xmit Power" on page 7-11 of this report, the Side B Ku-band transmitter power showed virtually no change over the entire time of Side B operation, while the Side A Ku receiver gain had a change of about 0.4 watts over an equal time span. Figure 7-16 "Side B, C Xmit Power" on page 7-10 indicates that the Side B C-band transmitter power decreased about 0.2 watts and the Side A C-band receiver gain increased by about 1 watt. For detailed Side A results, see NASA/ TM-2003-212236, Volume 12.

All the changes in transmitter powers and receiver gains for both Side A and B are acceptable aging changes.

After over 13 years of successful operation, the TOPEX mission ended. Numerous aging effects on spacecraft units led to operations not being practical to maintain the required earth pointing. A common spacecraft problem was the aging of optical couplers used in a number of units. The final failure that could not be recovered from was in the pitch wheel.

The last NASA altimeter data was taken on October 9, 2005. One of the last good ocean returns is shown in Figure 7-19 and Figure 7-20. These return waveforms are of the same quality as the first Side B returns in 1999 and first Side A returns in 1992. Both NASA altimeters performed exceptionally well and beyond all design goals and expectations.

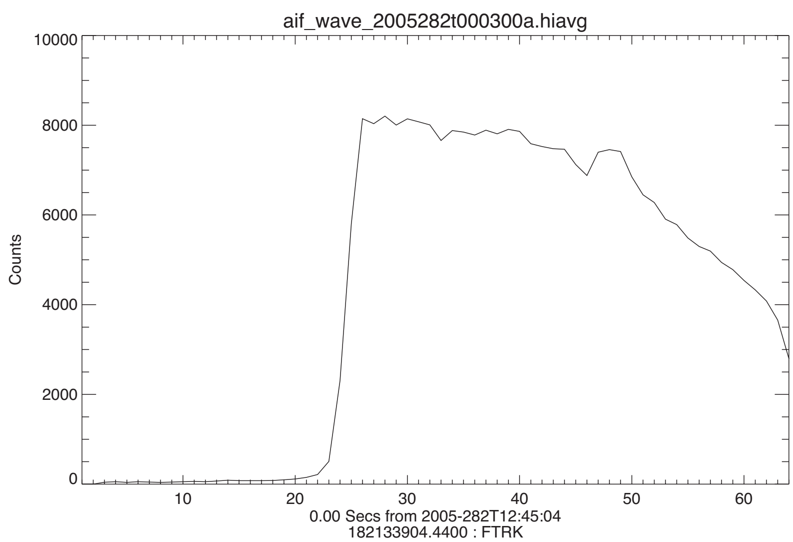

Figure 7-19 Hi Rate Waveform

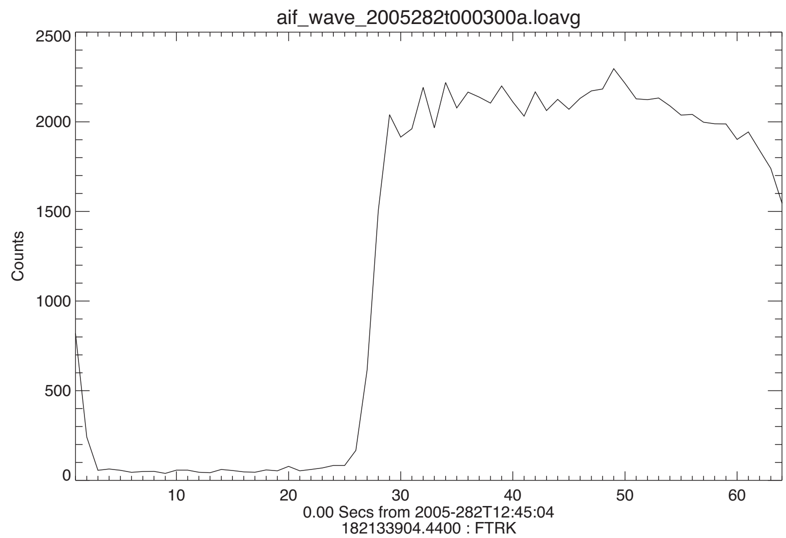

Figure 7-20 Low Rate Waveform

Appendix A
Cumulative Index of Studies

Tape Recorder (TR) Degradation - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2005*, NASA/TM-2005-212236, Volume 19, November 2005.

TOPEX/POSEIDON Follow-On, Jason-1 - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2005*, NASA/TM-2005-212236, Volume 19, November 2005.

Side B Point Target Response - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2005*, NASA/TM-2005-212236, Volume 19, November 2005.

Ancillary Performance Assessment Results, using the Differencing of the Ku-band and C-Band Data - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2005*, NASA/TM-2005-212236, Volume 19, November 2005.

Assessment of the Cycle-by-Cycle TOPEX Altimeter Range Measurement Noise Level by High-Pass Filtering 1-Hz Data - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2005*, NASA/TM-2005-212236, Volume 19, November 2005.

Land-to-Water Acquisition Times - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2005*, NASA/TM-2005-212236, Volume 19, November 2005.

Attitude Anomaly - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2005*, NASA/TM-2005-212236, Volume 19, November 2005.

Tape Recorder (TR) Degradation - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2004*, NASA/TM-2004-212236, Volume 18, April 2004.

TOPEX/POSEIDON Follow-On, Jason-1 - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2004*, NASA/TM-2004-212236, Volume 18, April 2004.

Side B Point Target Response - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2004*, NASA/TM-2004-212236, Volume 18, April 2004.

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Assessment of the Cycle-by-Cycle TOPEX Altimeter Range Measurement Noise Level by High-Pass Filtering 1-Hz Data - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2004* NASA/TM-2004-212236, Volume 18, April 2004.

Land-to-Water Acquisition Times - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2004*, NASA/TM-2004-212236, Volume 18, April 2004.

Attitude Anomaly - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2004*, NASA/TM-2004-212236, Volume 18, April 2004.

Blooms of σ^0 in the TOPEX Radar Altimeter Data - *Journal of Atmospheric and Oceanic Technology,* Volume 21, January 2004.

Cal Mode Range Drift - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2003*, NASA/TM-2004-212236, Volume 17, February 2004.

Tape Recorder (TR) Degradation - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2003*, NASA/TM-2004-212236, Volume 17, February 2004.

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Appendix B

Range Measurement Noise vs. SWH Statistical Indicators

Table B-1 Statistical Indicators Based on 1-Minute Track Segments

Time Period		SWH (m)		Noise Level (cm)		
Year	Cycle	Mean	STD	Mean	STD	at 2m SWH
1999	236	2.846	1.219	2.204	0.803	1.806
1999	237	2.840	1.314	2.168	0.798	1.784
1999	238	2.763	1.129	2.152	0.735	1.807
1999	239	2.789	1.235	2.151	0.769	1.789
1999	240	3.054	1.342	2.327	0.887	1.815
1999	241	2.951	1.203	2.220	0.755	1.803
1999	242	2.861	1.249	2.163	0.743	1.789
1999	244	2.895	1.430	2.195	0.830	1.800
1999	245	2.863	1.435	2.203	0.859	1.806
1999	246	2.891	1.390	2.221	0.829	1.814
1999	247	2.949	1.417	2.268	0.870	1.833
1999	248	2.873	1.429	2.204	0.842	1.813
1999	249	2.679	1.261	2.108	0.745	1.820
1999	250	2.984	1.574	2.248	0.885	1.808
1999	251	3.049	1.493	2.284	0.887	1.800
1999	252	2.931	1.478	2.233	0.870	1.814
1999	253	2.784	1.334	2.153	0.772	1.811
1999	254	2.843	1.486	2.185	0.869	1.795
1999	255	2.940	1.494	2.223	0.866	1.796
1999	257	2.845	1.381	2.177	0.797	1.804
1999	258	3.031	1.449	2.272	0.849	1.806
1999	259	2.786	1.407	2.161	0.849	1.794
1999	260	2.931	1.460	2.261	0.888	1.818
1999	261	2.913	1.387	2.207	0.833	1.788

Table B-1 Statistical Indicators Based on 1-Minute Track Segments (Continued)

Time Period		SWH (m)		Noise Level (cm)		
Year	Cycle	Mean	STD	Mean	STD	at 2m SWH
1999	262	2.811	1.294	2.157	0.776	1.796
1999	263	2.808	1.258	2.162	0.745	1.809
1999	264	2.719	1.204	2.127	0.737	1.808
1999	265	2.677	1.191	2.087	0.721	1.791
1999	267	2.651	1.238	2.104	0.792	1.786
1999	268	2.707	1.270	2.136	0.799	1.800
2000	269	2.599	1.227	2.069	0.761	1.790
2000	270	2.634	1.141	2.065	0.664	1.809
2000	271	2.692	1.198	2.129	0.756	1.804
2000	272	2.761	1.251	2.139	0.752	1.807
2000	273	2.903	1.295	2.230	0.847	1.786
2000	274	2.961	1.323	2.241	0.798	1.812
2000	275	2.955	1.314	2.231	0.805	1.791
2000	276	2.935	1.327	2.243	0.833	1.805
2000	277	2.968	1.274	2.247	0.830	1.796
2000	279	2.834	1.293	2.166	0.778	1.793
2000	280	2.898	1.313	2.196	0.790	1.803
2000	281	2.907	1.438	2.221	0.871	1.795
2000	282	3.055	1.565	2.336	0.936	1.836
2000	283	2.723	1.335	2.117	0.784	1.798
2000	284	2.832	1.291	2.185	0.811	1.799
2000	285	2.824	1.360	2.149	0.801	1.784
2000	286	2.879	1.450	2.206	0.845	1.805
2000	287	2.793	1.356	2.152	0.794	1.806
2000	288	2.918	1.460	2.231	0.865	1.811
2000	290	2.892	1.436	2.192	0.824	1.799
2000	291	2.890	1.456	2.208	0.872	1.791
2000	292	2.883	1.384	2.195	0.816	1.796
2000	293	2.756	1.403	2.155	0.817	1.810

Table B-1 Statistical Indicators Based on 1-Minute Track Segments (Continued)

Time Period		SWH (m)		Noise Level (cm)		
Year	Cycle	Mean	STD	Mean	STD	at 2m SWH
2000	294	2.811	1.422	2.174	0.833	1.800
2000	295	2.861	1.378	2.175	0.806	1.790
2000	296	2.932	1.355	2.211	0.785	1.815
2000	297	2.816	1.287	2.145	0.746	1.801
2000	298	2.793	1.269	2.152	0.779	1.803
2000	300	2.616	1.193	2.098	0.745	1.814
2000	301	2.799	1.240	2.161	0.779	1.788
2000	302	2.737	1.139	2.117	0.712	1.794
2000	303	2.676	1.233	2.109	0.770	1.793
2000	304	2.895	1.313	2.202	0.810	1.787
2000	305	2.765	1.179	2.138	0.746	1.789
2001	306	2.686	1.204	2.119	0.761	1.801
2001	308	2.756	1.130	2.123	0.716	1.784
2001	309	2.785	1.178	2.140	0.725	1.792
2001	310	2.726	1.131	2.114	0.699	1.798
2001	311	2.802	1.273	2.187	0.781	1.820
2001	312	2.931	1.316	2.245	0.840	1.806
2001	313	2.897	1.322	2.188	0.799	1.795
2001	314	2.872	1.291	2.186	0.775	1.810
2001	315	2.975	1.302	2.216	0.789	1.781
2001	316	2.906	1.331	2.206	0.810	1.803
2001	317	2.890	1.287	2.191	0.780	1.790
2001	318	2.947	1.466	2.253	0.894	1.803
2001	319	2.774	1.327	2.182	0.814	1.832
2001	320	2.720	1.309	2.124	0.773	1.806
2001	321	2.738	1.335	2.133	0.773	1.809
2001	322	2.781	1.274	2.135	0.743	1.801
2001	323	2.934	1.523	2.223	0.873	1.803
2001	324	2.973	1.432	2.237	0.840	1.801

Table B-1 Statistical Indicators Based on 1-Minute Track Segments (Continued)

Time Period		SWH (m)		Noise Level (cm)		
Year	**Cycle**	**Mean**	**STD**	**Mean**	**STD**	**at 2m SWH**
2001	325	2.904	1.508	2.235	0.903	1.808
2001	326	2.875	1.437	2.190	0.841	1.795
2001	327	3.053	1.473	2.274	0.870	1.794
2001	328	2.853	1.426	2.172	0.824	1.790
2001	329	2.820	1.324	2.166	0.766	1.808
2001	330	2.866	1.507	2.207	0.894	1.796
2001	331	3.156	1.450	2.321	0.858	1.790
2001	332	2.942	1.353	2.206	0.788	1.803
2001	333	2.980	1.362	2.237	0.825	1.780
2001	334	2.835	1.257	2.197	0.773	1.812
2001	335	2.643	1.156	2.084	0.711	1.796
2001	336	2.758	1.182	2.134	0.724	1.803
2001	337	2.861	1.189	2.174	0.770	1.771
2001	338	2.607	1.065	2.048	0.655	1.787
2001	339	2.728	1.116	2.096	0.670	1.790
2001	340	2.724	1.080	2.106	0.654	1.807
2001	341	2.637	1.071	2.066	0.671	1.795
2001	342	2.707	1.151	2.147	0.733	1.827
2002	343	2.876	1.362	2.217	0.886	1.776
2002	344	2.701	1.126	2.101	0.697	1.791
2002	345	2.802	1.158	2.140	0.749	1.777
2002	346	2.857	1.152	2.155	0.689	1.789
2002	347	2.749	1.105	2.122	0.676	1.811
2002	348	2.648	1.073	2.056	0.626	1.803
2002	349	2.750	1.137	2.115	0.714	1.785
2002	350	2.915	1.122	2.213	0.738	1.790
2002	351	2.951	1.189	2.190	0.712	1.783
2002	352	2.873	1.247	2.174	0.749	1.791
2002	353	2.925	1.262	2.221	0.790	1.791

Table B-1 Statistical Indicators Based on 1-Minute Track Segments (Continued)

Time Period		SWH (m)		Noise Level (cm)		
Year	Cycle	Mean	STD	Mean	STD	at 2m SWH
2002	354	2.921	1.334	2.214	0.826	1.781
2002	355	2.890	1.263	2.204	0.797	1.791
2002	356	2.854	1.300	2.187	0.803	1.788
2002	357	3.031	1.374	2.270	0.818	1.811
2002	358	2.875	1.280	2.172	0.766	1.788
2002	359	2.973	1.357	2.231	0.852	1.763
2002	360	3.073	1.389	2.283	0.842	1.781
2002	362	2.983	1.523	2.229	0.857	1.792
2002	363	3.221	1.446	2.321	0.821	1.801
2002	364	3.098	1.450	2.268	0.839	1.777
2002	365	3.073	1.422	2.273	0.871	1.764
2002	366	2.900	1.308	2.149	0.764	1.761
2002	367	2.920	1.393	2.227	0.844	1.793
2002	368	2.879	1.420	2.177	0.814	1.786
2002	369	2.891	1.246	2.184	0.755	1.787
2002	370	2.830	1.222	2.158	0.731	1.796
2002	371	2.944	1.289	2.230	0.801	1.790
2002	372	2.818	1.249	2.175	0.759	1.809
2002	373	2.668	1.166	2.089	0.683	1.811
2002	374	2.869	1.172	2.178	0.733	1.785
2002	375	2.740	1.104	2.112	0.722	1.767
2002	376	2.968	1.260	2.227	0.795	1.769
2002	377	2.802	1.056	2.129	0.686	1.771
2002	378	2.702	1.022	2.110	0.663	1.793
2002	379	2.893	1.297	2.195	0.806	1.769
2003	380	2.864	1.208	2.200	0.763	1.800
2003	381	2.891	1.239	2.185	0.777	1.770
2003	382	2.748	1.102	2.124	0.697	1.795
2003	383	2.810	1.184	2.173	0.753	1.795

Table B-1   Statistical Indicators Based on 1-Minute Track Segments (Continued)

Time Period		SWH (m)		Noise Level (cm)		
Year	Cycle	Mean	STD	Mean	STD	at 2m SWH
2003	384	2.954	1.284	2.249	0.804	1.811
2003	385	2.739	1.074	2.125	0.698	1.788
2003	386	2.907	1.252	2.187	0.750	1.787
2003	387	2.909	1.179	2.168	0.716	1.771
2003	388	2.836	1.143	2.182	0.721	1.804
2003	389	3.009	1.281	2.247	0.787	1.792
2003	390	3.011	1.256	2.238	0.757	1.791
2003	391	2.828	1.289	2.169	0.773	1.802
2003	392	2.790	1.186	2.141	0.710	1.797
2003	393	3.059	1.411	2.283	0.870	1.770
2003	394	2.844	1.265	2.188	0.759	1.821
2003	395	2.893	1.330	2.221	0.806	1.816
2003	396	2.960	1.463	2.247	0.860	1.798
2003	397	2.828	1.313	2.166	0.765	1.795
2003	398	2.849	1.373	2.152	0.792	1.784
2003	399	3.036	1.428	2.256	0.836	1.788
2003	400	3.066	1.501	2.282	0.893	1.775
2003	401	2.837	1.410	2.170	0.801	1.799
2003	402	2.674	1.382	2.092	0.783	1.798
2003	403	2.726	1.285	2.108	0.757	1.791
2003	404	2.612	1.182	2.069	0.729	1.791
2003	405	2.892	1.427	2.182	0.799	1.801
2003	406	2.744	1.277	2.141	0.760	1.817
2003	407	2.738	1.149	2.118	0.678	1.815
2003	408	2.819	1.184	2.154	0.738	1.787
2003	409	2.717	1.163	2.107	0.678	1.810
2003	410	2.761	1.178	2.128	0.741	1.779
2003	411	2.808	1.041	2.148	0.663	1.799
2003	412	2.729	1.179	2.123	0.734	1.792

Table B-1 Statistical Indicators Based on 1-Minute Track Segments (Continued)

Time Period		SWH (m)		Noise Level (cm)		
Year	Cycle	Mean	STD	Mean	STD	at 2m SWH
2003	413	2.888	1.199	2.204	0.773	1.788
2003	414	2.809	1.108	2.164	0.756	1.779
2003	415	2.799	1.051	2.162	0.811	1.789
2003	416	2.598	1.076	2.027	0.664	1.766
2004	417	2.822	1.311	2.180	0.789	1.804
2004	418	2.623	1.104	2.082	0.663	1.824
2004	419	2.620	1.048	2.062	0.649	1.792
2004	420	2.698	1.178	2.109	0.740	1.785
2004	421	2.897	1.274	2.214	0.775	1.806
2004	422	2.899	1.114	2.184	0.694	1.801
2004	423	2.844	1.160	2.169	0.729	1.789
2004	424	2.869	1.156	2.190	0.731	1.804
2004	425	2.949	1.288	2.217	0.803	1.775
2004	426	2.930	1.267	2.224	0.777	1.794
2004	427	2.994	1.283	2.270	0.808	1.797
2004	428	2.945	1.334	2.238	0.835	1.784
2004	429	2.483	1.048	2.016	0.662	1.811
2004	430	2.749	1.377	2.163	0.822	1.819
2004	433	3.015	1.486	2.268	0.869	1.800
2004	434	2.709	1.093	2.060	0.632	1.771
2004	435	2.738	1.248	2.144	0.812	1.776
2004	436	2.936	1.435	2.221	0.864	1.782
2004	437	2.663	1.338	2.078	0.759	1.786
2004	438	2.852	1.356	2.183	0.808	1.793
2004	439	2.822	1.178	2.144	0.699	1.796
2004	440	2.729	1.258	2.139	0.756	1.808
2004	441	2.899	1.415	2.212	0.835	1.797
2004	442	2.873	1.291	2.212	0.805	1.807
2004	443	2.664	1.158	2.084	0.736	1.777

Table B-1 Statistical Indicators Based on 1-Minute Track Segments (Continued)

Time Period		SWH (m)		Noise Level (cm)		
Year	Cycle	Mean	STD	Mean	STD	at 2m SWH
2004	444	2.776	1.159	2.143	0.689	1.818
2004	445	2.717	1.077	2.092	0.671	1.777
2004	446	2.783	1.177	2.123	0.700	1.785
2004	447	2.639	1.029	2.061	0.643	1.800
2004	448	2.732	1.152	2.123	0.725	1.783
2004	449	2.691	1.209	2.091	0.739	1.780
2004	450	2.718	1.085	2.115	0.723	1.776
2004	451	2.912	1.273	2.196	0.789	1.794
2004	452	2.686	1.109	2.106	0.693	1.795
2004	**453**	**2.662**	**1.089**	**2.091**	**0.696**	**1.785**
2005	**454**	**2.849**	**1.319**	**2.206**	**0.849**	**1.788**
2005	**455**	**2.708**	**1.130**	**2.096**	**0.675**	**1.793**
2005	**456**	**2.861**	**1.107**	**2.168**	**0.702**	**1.791**
2005	**457**	**2.720**	**1.060**	**2.109**	**0.677**	**1.798**
2005	**458**	**2.705**	**1.190**	**2.118**	**0.722**	**1.806**
2005	**459**	**2.999**	**1.310**	**2.256**	**0.837**	**1.777**
2005	**460**	**2.891**	**1.138**	**2.188**	**0.731**	**1.780**
2005	**461**	**2.724**	**1.114**	**2.125**	**0.703**	**1.797**
2005	**462**	**2.860**	**1.220**	**2.185**	**0.769**	**1.792**
2005	**463**	**2.963**	**1.216**	**2.223**	**0.771**	**1.782**
2005	**464**	**2.788**	**1.203**	**2.152**	**0.753**	**1.793**
2005	**465**	**2.852**	**1.324**	**2.190**	**0.812**	**1.785**
2005	**466**	**2.726**	**1.124**	**2.113**	**0.705**	**1.784**
2005	**467**	**2.795**	**1.251**	**2.147**	**0.740**	**1.799**
2005	**468**	**2.817**	**1.304**	**2.166**	**0.762**	**1.800**
2005	**469**	**2.775**	**1.250**	**2.137**	**0.728**	**1.799**
2005	**470**	**2.670**	**1.246**	**2.108**	**0.760**	**1.798**
2005	**471**	**2.790**	**1.390**	**2.140**	**0.771**	**1.807**
2005	**472**	**2.915**	**1.432**	**2.238**	**0.857**	**1.808**

Table B-1 Statistical Indicators Based on 1-Minute Track Segments (Continued)

Time Period		SWH (m)		Noise Level (cm)		
Year	Cycle	Mean	STD	Mean	STD	at 2m SWH
2005	**473**	**2.778**	**1.256**	**2.133**	**0.718**	**1.801**
2005	**474**	**2.603**	**1.212**	**2.054**	**0.725**	**1.794**
2005	**475**	**2.677**	**1.397**	**2.098**	**0.807**	**1.792**
2005	**476**	**2.697**	**1.384**	**2.114**	**0.789**	**1.806**
2005	**477**	**2.848**	**1.336**	**2.199**	**0.808**	**1.802**
2005	**478**	**2.866**	**1.346**	**2.206**	**0.822**	**1.807**
2005	**479**	**2.759**	**1.231**	**2.122**	**0.701**	**1.801**
2005	**480**	**2.810**	**1.364**	**2.133**	**0.805**	**1.764**
2005	**481**	**2.820**	**1.363**	**2.169**	**0.781**	**1.804**

Note:

- Cycles 243, 256, 266, 278, 289, 299, 307, and 361 are omitted in Table B-1 because they occurred during CNES SSALT operations.
- The statistical indicators since last update are indicated by **bold** type.

Appendix C
NASA Altimeter Key Events

Table C-1 NASA Altimeter Side A - Key Events

Day	Event
1992/234	Altimeter Turned On to IDLE Mode
1992/238	First TRACK
1992/240	Safehold During Inclination Maneuver
1992/242	Returned to TRACK Mode
1992/242	Turned Off by TMON at Start of Eclipse
1992/242	Returned to TRACK Mode
1992/247	Improper SEU Recovery due to Corruption of Pulse Count Variable
1992/268	Safehold
1992/269	Returned to TRACK Mode
1992/304	50ms Acquisition Parameter Set Upload
1992/328	Software Patch to Refresh Pulse Count (see Day 247 above)
1992/354	Loss of Science Data and Clock Between SEUs (lost 16 hours of data)
1993/012	Improper SEU Recovery (lost 12 min. of data)
1993/033	Transmit Test
1993/069	Digital Filter-Bank Leakage Test
1993/089	Turned Off by TMON
1993/089	Changed to IDLE Mode For SSALT
1993/089	Returned to TRACK Mode
1993/089	Changed to IDLE Mode for SSALT
1993/099	Returned to TRACK Mode
1993/198	Changed to IDLE Mode For SSALT
1993/208	Returned to TRACK Mode
1993/218	Turned Off by TMON

Table C-1 NASA Altimeter Side A - Key Events (Continued)

Day	Event
1993/219	Returned to TRACK Mode
1993/230	Improper SEU Recovery (lost 1.5 hours of data)
1993/264	Improper SEU Recovery (lost 14.5 hours of data)
1993/266	Improper SEU Recovery (lost 7.5 hours of data)
1993/297	Changed to IDLE Mode For SSALT
1993/307	Returned to TRACK Mode
1993/307	Improper SEU Recovery (lost 2.3 hours of data)
1993/330	Improper SEU Recovery (lost 8.2 hours of data)
1994/001	Improper SEU Recovery (lost 3.7 hours of data)
1994/041	Transmit Test
1994/042	Transmit Test
1994/045	Transmit Test
1994/071	Changed to IDLE Mode For SSALT
1994/081	Returned to TRACK Mode
1994/112	Improper SEU Recovery (lost 1.1 hours of data)
1994/170	Changed to IDLE Mode For SSALT
1994/180	Returned to TRACK Mode
1994/256	Improper SEU Recovery (lost 4.3 hours of data)
1994/288	Improper SEU Recovery (lost 2.5 hours of data)
1994/294	Improper SEU Recovery (lost 1.3 hours of data)
1994/309	Changed to IDLE Mode for SSALT
1994/319	Returned to TRACK Mode
1994/324	Improper SEU Recovery (lost 3.1 hours of data)
1995/013	Warm boot (lost 0.7 hours of data)
1995/040	Changed Operating Parameter Set for Faster Acquisition after a Reset
1995/040	Digital Filter-Bank Leakage Test (lost 0.3 hours of data)
1995/063	Changed to IDLE Mode for SSALT

Table C-1 NASA Altimeter Side A - Key Events (Continued)

Day	Event
1995/073	Returned to TRACK Mode
1995/083	Improper SEU Recovery (lost 1.6 hours of data)
1995/123	Changed to IDLE Mode for SSALT
1995/132	Returned to TRACK Mode
1995/157	Improper SEU Recovery (lost 8.4 hours of data)
1995/182	Changed to IDLE Mode for SSALT
1995/192	Returned to TRACK Mode
1995/251	Improper SEU Recovery (lost 3.9 hours of data)
1995/291	Changed to IDLE Mode for SSALT
1995/301	Returned to TRACK Mode
1995/306	Improper SEU Recovery (lost 3.4 hours of data)
1995/325	Improper SEU Recovery (lost 1.8 hours of data)
1995/327	Improper SEU Recovery (lost 3.5 hours of data)
1995/330	Spacecraft Safehold (lost 230 hours of data)
1995/340	Returned to TRACK Mode
1995/361	Improper SEU Recovery (lost 3.3 hours of data)
1996/019	Warm boot (lost 2.0 hours of data)
1996/020	Spacecraft Safehold (lost 68 hours of data)
1996/040	Digital Filter-Bank Leakage Test (lost 0.3 hours of data)
1996/041	Improper SEU Recovery (lost 3.1 hours of data)
1996/046	Changed to IDLE Mode for SSALT
1996/056	Returned to TRACK Mode
1996/057	Improper SEU Recovery (lost 2.2 hours of data)
1996/058	Turned Off by TMON (lost 5.3 hours of data)
1996/077	Improper SEU Recovery (lost 1.6 hours of data)
1996/083	Onboard Tape Recorder Problem (lost 0.5 hours of data)
1996/150	Onboard Tape Recorder Problem (lost 1.6 hours of data)

Table C-1 NASA Altimeter Side A - Key Events (Continued)

Day	Event
1996/162	Warm boot (lost 0.8 hours of data)
1996/164	Changed to IDLE Mode for SSALT
1996/174	Returned to TRACK Mode
1996/178	Onboard Tape Recorder Problem (lost 0.4 hours of data)
1996/187	Warm boot (lost 0.7 hours of data)
1996/197	Improper SEU Recovery (lost 1.1 hours of data)
1996/217	Improper SEU Recovery (lost 2.8 hours of data)
1996/226	Improper SEU Recovery (lost 4.9 hours of data)
1996/236	Digital Filter-Bank Leakage Test (lost 0.8 hours of data)
1996/263	Turned off by TMON (lost 19.0 hours of data)
1996/283	Changed to IDLE Mode for SSALT
1996/293	Returned to TRACK Mode
1996/362	C-Band Transmit on Side B (lost 4.8 hours of data)
1997/036	Changed to IDLE Mode for SSALT
1997/046	Returned to TRACK Mode
1997/084	Digital Filter-Bank Leakage Test (lost 0.6 hours of mostly land data)
1997/099	Improper SEU Recovery (lost 1.0 hours of data)
1997/155	Changed to IDLE Mode for SSALT
1997/165	Returned to TRACK Mode
1997/215	Changed to IDLE Mode for SSALT
1997/224	Returned to TRACK Mode
1997/237	Improper SEU Recovery (lost 1.6 hours of data)
1997/253	Improper SEU Recovery (lost 4.1 hours of data)
1997/267	Digital Filter-Bank Leakage Test (lost 0.3 hours of land data)
1997/268	Improper SEU Recovery (lost 2.8 hours of data)
1997/274	Changed to IDLE Mode for SSALT
1997/284	Returned to TRACK Mode

Table C-1 NASA Altimeter Side A - Key Events (Continued)

Day	Event
1997/332	Improper SEU Recovery (lost 3.5 hours of data)
1997/343	Uploaded Extended AGC Software (lost 1.4 hours of data)
1997/346	Uploaded Extended AGC Software (lost 0.4 hours of land data)
1997/347	Uploaded Extended AGC Software (lost 0.3 hours of land data)
1997/349	ASTRA1-A SEU (off-nadir excursion affected 11.9 hours of data)
1998/013	Improper SEU Recovery (lost 3.9 hours of data)
1998/018	Changed to IDLE Mode for SSALT
1998/028	Returned to TRACK Mode
1998/028	Uploaded Extended AGC Software (lost 0.3 hours of land data)
1998/029	Tested Extended AGC Software (lost 0.7 hours of mostly land data)
1998/037	Tested Extended AGC Software (lost 0.3 hours of mostly land data)
1998/044	Enabled Extended AGC Software (lost 0.1 hours of mostly land data)
1998/077	LAM (off-nadir excursion affected 3.0 hours of data - data still usable)
1998/098	Digital Filter-Bank Leakage Test (lost 0.3 hours of land data)
1998/137	Changed to IDLE Mode for SSALT
1998/147	Returned to TRACK Mode
1998/155	Command Generation Error (lost 7.3 hours of data)
1998/164	Improper SEU Recovery (lost 3.4 hours of data)
1998/204	Transmit Test (lost 0.8 hours of data)
1998/205	Digital Filter-Bank Leakage Test (lost 0.2 hours of data)
1998/206	Changed to IDLE Mode for SSALT
1998/216	Returned to TRACK Mode
1998/224	C100 CAL Mode Test (lost 0.1 hours of land data)
1998/243	Improper SEU Recovery (lost 2.7 hours of data)
1998/250	Loaded Cal Sweep Software (lost 0.2 hours of land data)
1998/251	Executed Cal Sweep Software (lost 0.5 hours of land data)
1998/254	Improper SEU Recovery (lost 2.5 hours of data)

Table C-1 NASA Altimeter Side A - Key Events (Continued)

Day	Event
1998/280	Executed Cal Sweep Software (lost 0.5 hours of land data)
1998/286	Changed to IDLE Mode for SSALT
1998/296	Returned to TRACK Mode
1998/296	Improper SEU Recovery (lost 2.1 hours of data)
1998/321	Changed to IDLE Mode for Leonid Meteor Shower (lost 6.0 hours of data)
1998/335	Changed to IDLE Mode for Orbital Maneuver (lost 2.4 hours of data)
1998/349	Executed Cal Sweep Software (lost 0.4 hours of land data)
1999/020	Changed to IDLE Mode for SSALT
1999/030	Returned to TRACK Mode
1999/040	Special Testing Prior to Side A Turn-Off (Testing Began at 1604 UTC and Ended at 2350 UTC)
1999/041	Side A Turn-Off at 02:55:30 UTC for Side B Testing

Table C-2 NASA Altimeter Side B - Key Events

Day	Event
1999/041	Commanded Side B to IDLE Mode and Uploaded Memory Patches
1999/042	Commanded Side B to STANDBY and then to TRACK Mode
1999/042	Side B Testing, including: Mode Checks, Cal-Sweep, and Waveform Leakage Tests
1999/043	Additional Testing, including: Cal-Sweep, Waveform Leakage Tests, and Gate-Shift Tests
1999/048	Gate Shift Tests (lost 3.1 hours of data)
1999/049	Cal-Sweep Test (lost 0.4 hours of overland data)
1999/049-050	Off-Nadir Tests
1999/050	Began First Side B Operational Cycle [Cycle 237]
1999/071	Improper SEU Recovery (lost 0.7 hours of data)
1999/089	Cal-Sweep Test (lost 0.4 hours of overland data)
1999/109	Cal-Sweep Test (lost 0.4 hours of overland data)

Table C-2 NASA Altimeter Side B - Key Events (Continued)

Day	Event
1999/109	Changed to IDLE Mode for SSALT
1999/119	Returned to TRACK Mode
1999/119	Cal-Sweep Test (lost 0.4 hours of overland data)
1999/149	Cal-Sweep Test (lost 0.4 hours of overland data)
1999/179	Cal-Sweep Test (lost 0.4 hours of overland data)
1999/198-199	C-Band Autonomously Switched to Side A Transmit (lost 5.6 hours of data)
1999/209	Cal-Sweep Test (lost 0.4 hours of overland data)
1999/223	C-Band CAMPIN Autonomously Disabled (lost 1.6 hours of data). Some corruption of Non-Protected Memory
1999/226	Unsuccessful Restoration of Non-Protected Memory, due to Command Table Error (lost 0.6 hours of overland data)
1999/231	Successful Restoration of Non-Protected Memory (lost 1.1 hours of mostly overland data)
1999/236	Commanding for New Parameter File, to Increase AGC Minimum from 13 to 15 dB (lost 0.1 hours of overland data).
1999/237	Cal-Sweep Test (lost 0.4 hours of overland data)
1999/238	Changed to IDLE Mode for SSALT
1999/243	Spacecraft Safehold, after a reset of central data processing unit. ALT was automatically turned OFF.
1999/243	Commanded ALT back to IDLE Mode. Total OFF time was 15.7 hours.
1999/244	Uploaded full memory dump command. ALT remains in IDLE.
1999/245	ALT turned OFF during Attitude Control Electronics switchover
1999/246	Commanded ALT back to IDLE Mode and Uploaded full memory dump command. ALT remains in IDLE. OFF time was 7.9 hours.
1999/248	Returned to TRACK Mode
1999/252	Digital Filter Bank Calibration (lost 0.3 hours of overland data)
1999/265	Sent Commands in Attempt to Improve Acquisition. Lost 1.1 hours of land and ocean data. Commanding was Unsuccessful.
1999/268	Cal-Sweep Test (lost 0.4 hours of overland data)

Table C-2 NASA Altimeter Side B - Key Events (Continued)

Day	Event
1999/276	Ku-Band Autonomously Switched to Side A Transmit (lost 3.1 hours of data)
1999/298	Cal-Sweep Test (lost 0.4 hours of overland data)
1999/327	Cal-Sweep Test (lost 0.4 hours of overland data)
1999/337	Changed to IDLE Mode for SSALT
1999/347	Returned to TRACK Mode
1999/357	Cal-Sweep Test (lost 0.4 hours of overland data)
1999/360	SEU resulted in corruption of the engineering Pass Count value. No apparent effect on ALT science data.
2000/012	Orbital Maneuver #13 (affected 1.2 hours of data)
2000/022	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/036	Digital Filter Bank Calibration (lost 0.3 hours of overland data)
2000/052	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/056-061	SEU at 056/141130 UTC resulted in corrupted engineering spare word. Memory reload on 061/070828 UTC corrected problem. ALT science data quality during the interim was apparently not affected.
2000/061	Reloaded memory to rectify engineering memory corruption which began on day 056. Lost 0.9 hours of mostly overland data. This memory reload also restored the engineering Pass Count value which had been corrupted by an earlier SEU on 1999/360.
2000/067	Improper SEU recovery (lost 5.8 hours of data)
2000/081	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/091	Changed to IDLE Mode for SSALT
2000/101	Returned to TRACK Mode
2000/111	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/141	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/157	Improper SEU recovery (lost 1.9 hours of data)
2000/171	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/200	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/200	Changed to IDLE Mode for SSALT

Table C-2 NASA Altimeter Side B - Key Events (Continued)

Day	Event
2000/210	Returned to TRACK Mode
2000/227	Improper SEU recovery (lost 1.4 hours of data)
2000/230	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/260	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/275	Improper SEU recovery (lost 1.1 hours of data)
2000/290	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/299	Changed to IDLE Mode for SSALT
2000/309	Returned to TRACK Mode
2000/319	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/322	Changed to IDLE Mode for Leonid Meteor Shower (lost 2.0 hours of data)
2000/329	Spacecraft Safehold, ALT was automatically turned OFF due to bad ephemeris load.
2000/330	Commanded Alt back to Track. Total off time was 27.1 hours.
2000/349	Cal-Sweep Test (lost 0.4 hours of overland data)
2000/352	Attitude Excursion to about 0.21 degrees for about 2000 seconds
2001/012	Cal-Sweep Test (lost 0.4 hours of overland data)
2001/013	Changed to IDLE Mode for SSALT
2001/023	Returned to TRACK Mode
2001/036	The 'non-nominal' switch to Yaw Steering was caused by an OBC Euler-C Flag not being reset following the bad ephemeris load and Safehold of 11/23/00. (Flag was not reset due to an erroneous reinitialization command file). Lost 0.4 hours of data.
2001/043	Cal-Sweep Test (lost 0.4 hours of overland data)
2001/070	Improper SEU recovery (lost 0.02 hours of data)
2001/072	Cal-Sweep Test (lost 0.4 hours of overland data)
2001/079	Improper SEU recovery (lost 1.33 hours of data)
2001/101	Digital Filter-Bank Leakage Test and Transmit Test (lost 0.9 hours of data)

Table C-2 NASA Altimeter Side B - Key Events (Continued)

Day	Event
2001/102	Cal-Sweep Test (lost 0.4 hours of overland data)
2001/112	Improper SEU recovery (lost 1.30 hours of data)
2001/132	Cal-Sweep Test (lost 0.4 hours of overland data)
2001/162	Cal-Sweep Test (lost 0.4 hours of overland data)
2001/166	Improper SEU recovery (lost 0.01 hours of data)
2001/173-174	Improper SEU recovery (lost 3.23 hours of data)
2001/191	Cal-Sweep Test (lost 0.4 hours of overland data)
2001/205	Improper SEU recovery (lost 3.00 hours of data)
2001/217	Improper SEU recovery (lost 6.45 hours of data)
2001/221	Cal-Sweep Test (lost 0.4 hours of overland data)
2001/251	Cal-Sweep Test (lost 0.4 hours of overland data)
2001/258-261	SEU at 258/175123 UTC resulted in corrupted science spare word. Memory reload started on 261/035412 UTC corrected problem. ALT science data quality during the interim was apparently not affected.
2001/261	Reloaded memory to rectify science memory corruption which began on day 258. Lost 0.72 hours of mostly overland data.
2001/281	Cal-Sweep Test (lost 0.4 hours of overland data)
2001/310	Cal-Sweep Test (lost 0.4 hours of overland data)
2001/322	Changed to IDLE Mode for Leonid Meteor Shower (lost 17.0 hours of data)
2001/340	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/005	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/020	Failed Digital Filter-Bank Leakage Test (lost 1.8 hours of data)
2002/035	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/064	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/094	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/124	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/154	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/183	Cal-Sweep Test (lost 0.4 hours of overland data)

Table C-2 NASA Altimeter Side B - Key Events (Continued)

Day	Event
2002/183	Changed to IDLE Mode for SSALT
2002/193	SSALT seu prevented transmit power enable (lost 0.5 hours of data) during a transition from SSALT to ALT. Returned to TRACK Mode
2002/213	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/223	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/227	Start TOPEX Orbit Transfer Maneuver (TOTM). TOTM-D227, Burn 1 of 6.
2002/231	TOTM-D231, Burn 2 of 6.
2002/233	Cal-Sweep Test. ALT CAL1 Sweep Test was unsuccessful due to data loss of 0.8 hours.
2002/235	TOTM-D235, Burn 3 of 6.
2002/243	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/253	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/253	TOTM-D253A & TOTM-D253B, Burn 4a & 4b of 6.
2002/256	TOTM-D256, Burn 5 of 6.
2002/259	Completed TOPEX Orbit Transfer Maneuver. TOTM-D259, Burn 6 of 6.
2002/263	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/273	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/283	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/292	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/302	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/312	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/322	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/323	Changed to IDLE Mode for Leonid Meteor Shower (lost 13.0 hours of data)
2002/332	Cal-Sweep Test (lost 0.4 hours of overland data)
2002/342	Cal-Sweep Test (lost 0.4 hours of overland data). ALT CAL1 Sweep Test was invalidated by an [erroneously-scheduled] ALT calibration command file.

Table C-2 NASA Altimeter Side B - Key Events (Continued)

Day	Event
2002/352	Cal-Sweep Test (lost 0.4 hours of overland data).
2002/362	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/007	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/017	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/027	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/037	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/046	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/056	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/066	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/076	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/086	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/096	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/106	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/116	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/126	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/136	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/146	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/156	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/165	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/175	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/185	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/195	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/205	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/215	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/225	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/235	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/245	Cal-Sweep Test (lost 0.4 hours of overland data).

Table C-2 NASA Altimeter Side B - Key Events (Continued)

Day	Event
2003/255	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/265	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/275	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/284	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/294	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/303-310	SEU at 303/125511 UTC resulted in corrupted science spare word. Memory reload started on 310/022301 UTC corrected problem. ALT science data quality during the interim was apparently not affected.
2003/310	Reloaded memory to rectify science memory corruption which began on day 303. Lost 0.72 hours of mostly overland data.
2003/314	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/324	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/334	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/344	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/354	Cal-Sweep Test (lost 0.4 hours of overland data).
2003/364	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/009	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/019	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/028-029	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/038	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/048	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/058	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/068	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/078	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/088	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/098	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/108	Cal-Sweep Test (no data available).
2004118	Cal-Sweep Test (lost 0.4 hours of overland data).

Table C-2 NASA Altimeter Side B - Key Events (Continued)

Day	Event
2004128	Cal-Sweep Test (lost 0.4 hours of overland data).
2004138	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/147	Spacecraft in Safehold mode due to a roll reaction wheel failure.
2004/164	Commanded Alt back to Track. Total off time was 16 days, 7 hours, 52 minutes.
2004/167	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/177	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/187	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/197	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/207	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/217	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/227	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/237	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/247	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/257	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/266	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/276	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/286	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/296	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/306	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/316	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/326	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/336	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/340-342	SEU at 340/194845 UTC resulted in corrupted science spare word. Memory reload started on 342/204924 UTC to correct the problem. ALT science data quality during the interim was apparently not affected.
2004/342	Reloaded memory to rectify science memory corruption which began on day 2004342. Lost 37 minutes (0.62 hours) of mostly overland data.
2004/346	Cal-Sweep Test (lost 0.4 hours of overland data).

Table C-2 NASA Altimeter Side B - Key Events (Continued)

Day	Event
2004/352	Spacecraft in Safehold mode due to a pitch reaction wheel failure.
2004/353	Commanded Alt back to Track. Total off time was 25 hours, 16 minutes.
2004/356	Cal-Sweep Test (lost 0.4 hours of overland data).
2004/366	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/010	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/019	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/030	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/038	The Pitch Wheel hung up during yesterday's Yaw Flip, but, after a cooling off period, it was restarted and the maneuver was successfully completed. Due to an Interface Lock-up when the Spacecraft lost Earth-Pointing (prior to ALT Turn-Off) ALT data loss was 4 hours, 6 minutes. Commanded Alt back to Track.
2005/040	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/050	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/060	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/072	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/080	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/090	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/100	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/109	The Pitch Wheel hung up during the maneuver and did not respond to the automatic kick-start. The wheel was turned Off and allowed to cool down. The kick-start was successful at the lower temperature and the maneuver was completed and attitude control restored (the ADCS remained on OBC control for the entire period; the Spacecraft did not enter the SPSHM Mode). As a result of the temporary loss attitude control due to the pitch wheel the Spacecraft drifted off Earth-Point and the Solar Array pointed off the Sun, causing TMON22 to turn Off the Altimeter. ALT data loss was 4 hours, 36 minutes. Commanded Alt back to Track.
2005/110	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/120	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/129	Cal-Sweep Test (lost 0.4 hours of overland data).

Table C-2 NASA Altimeter Side B - Key Events (Continued)

Day	Event
2005/149	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/159	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/169	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/179	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/189	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/199	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/209	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/219	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/229	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/239	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/248	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/258	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/268	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/278	Cal-Sweep Test (lost 0.4 hours of overland data).
2005/282	The Spacecraft lost attitude control at approximately 2005282t13:05 UTC due to a suspected pitch wheel anomaly. It was commanded to Safe-hold at 2005282t13:14 UTC. Subsequent attempts to restore nominal wheel operation were unsuccessful.

Appendix D
Engineering Monitor Results for 2005

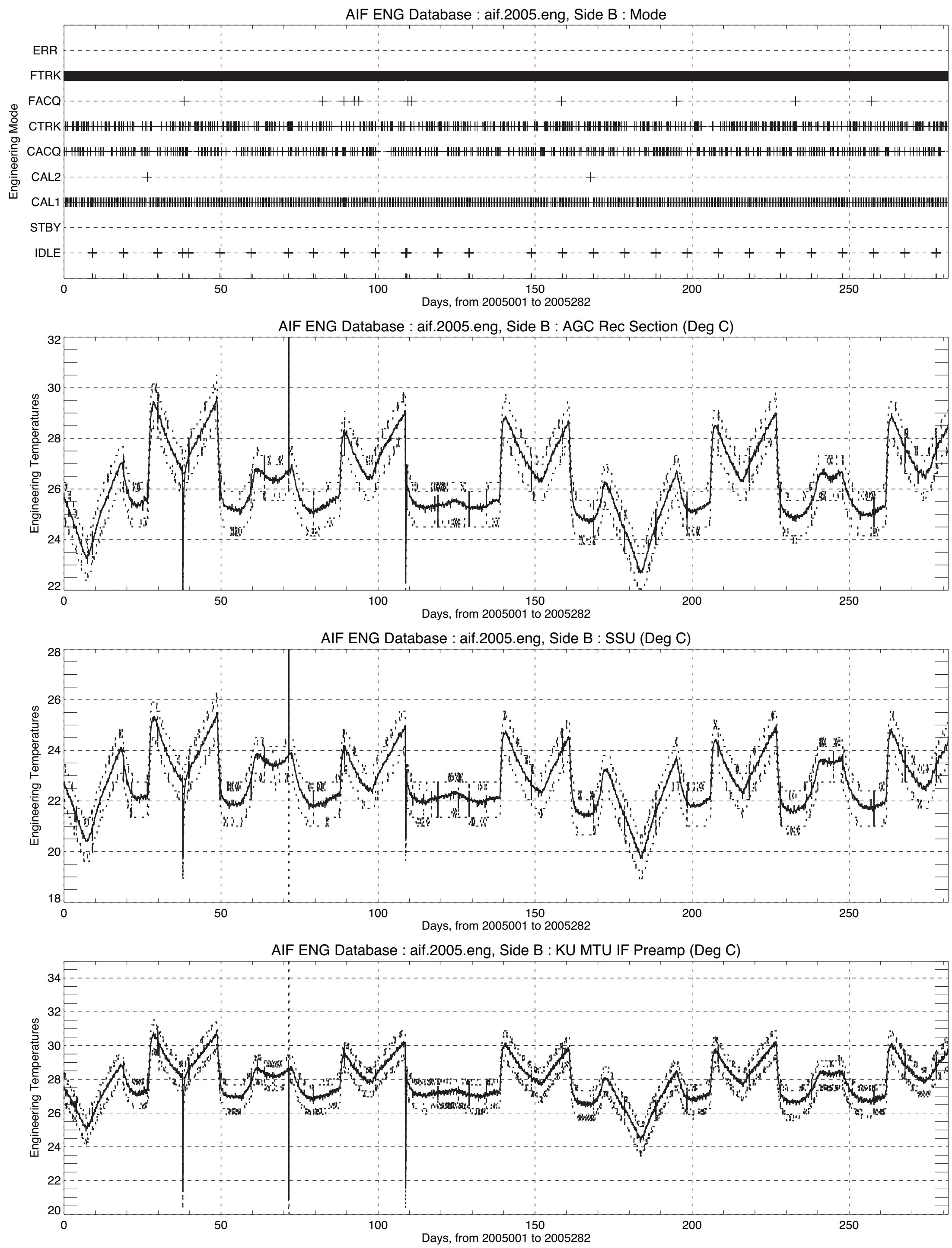
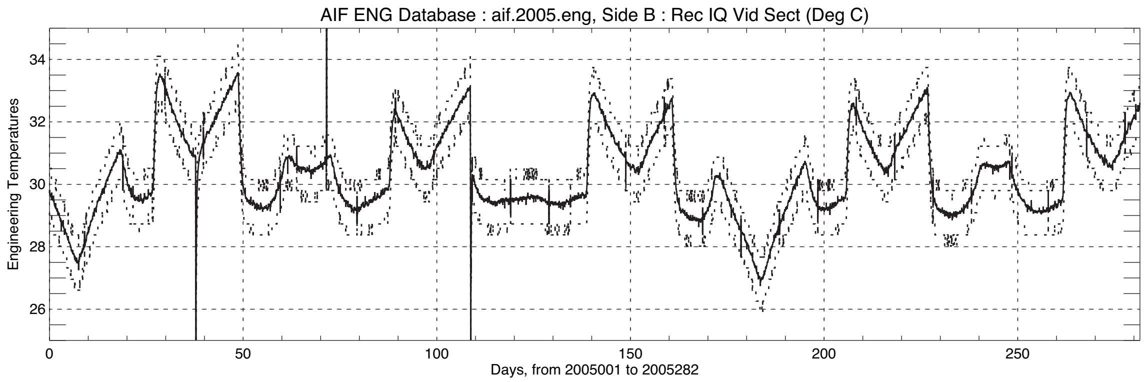
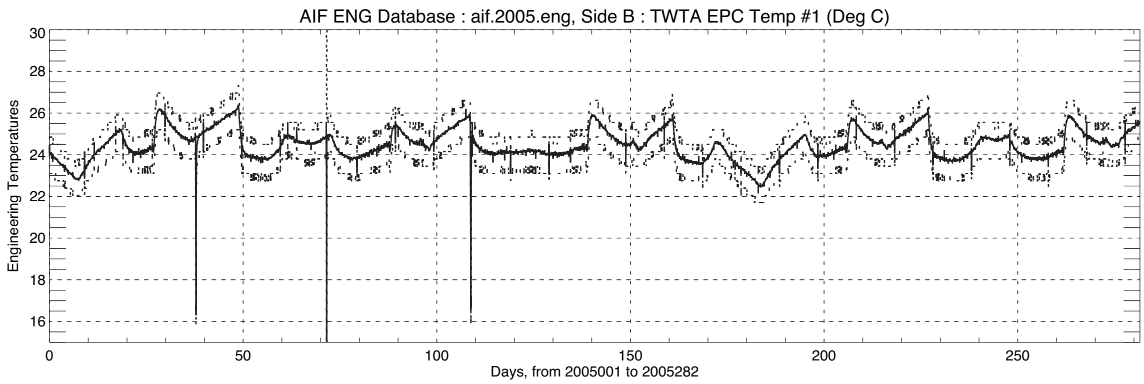
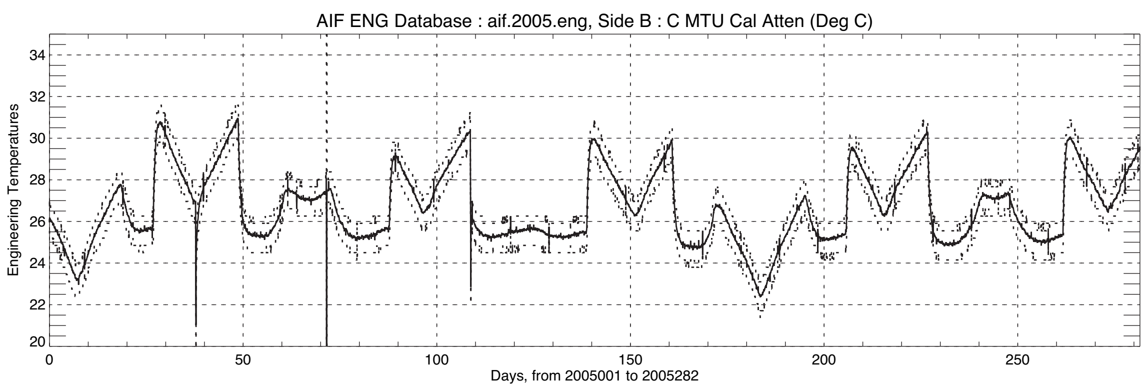


Figure D-1 Engineering Monitor Results for 2005







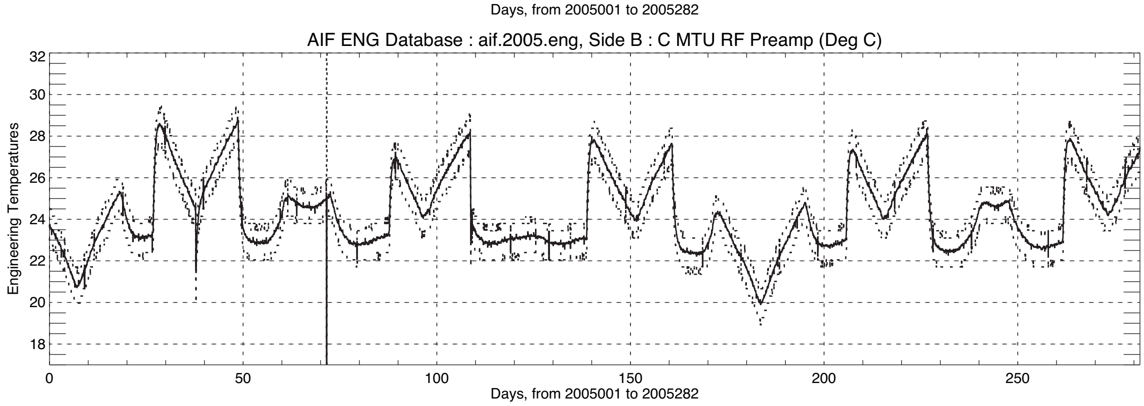


Figure D-1 Engineering Monitor Results for 2005 (Continued)

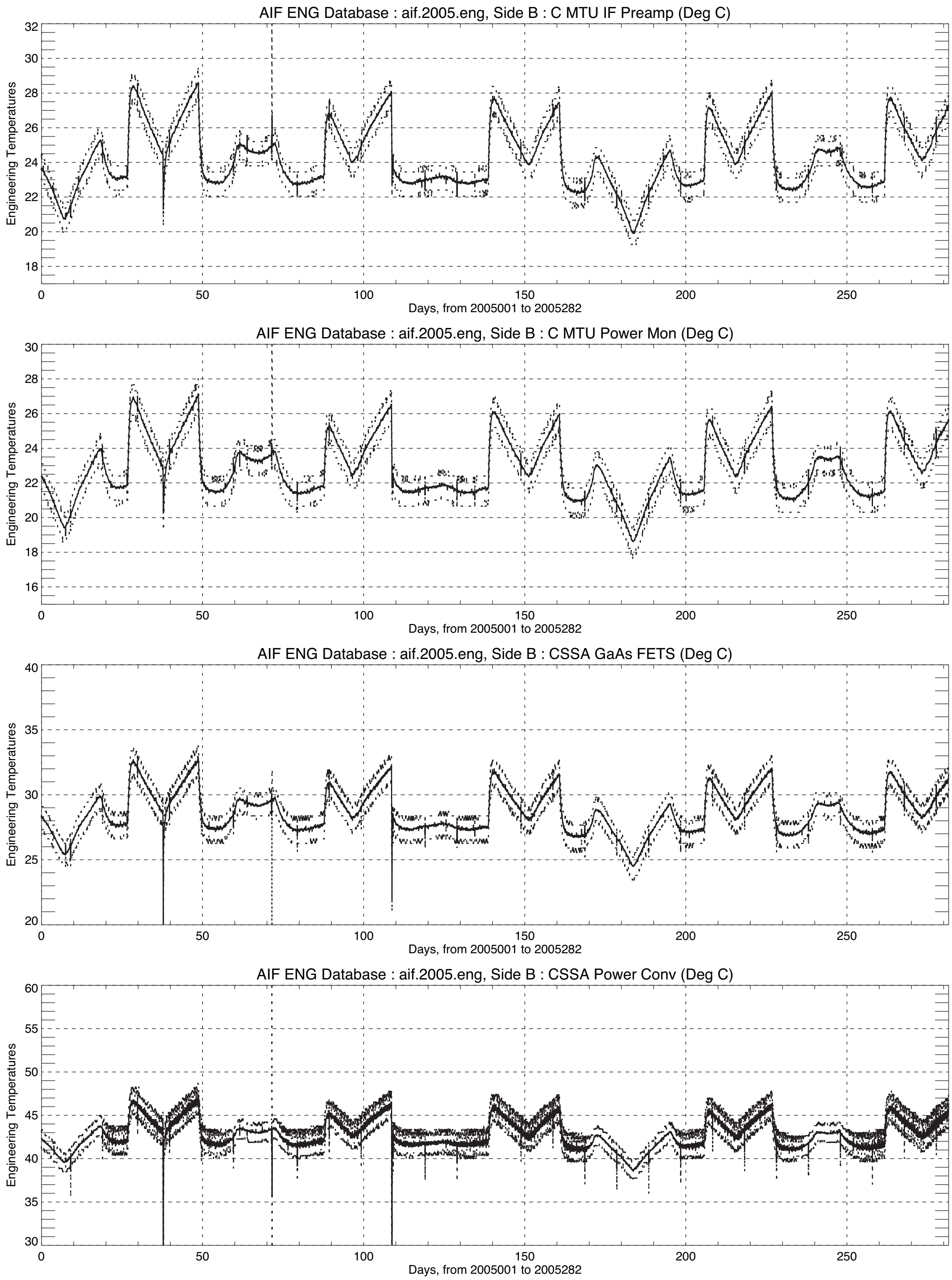


Figure D-1 Engineering Monitor Results for 2005 (Continued)

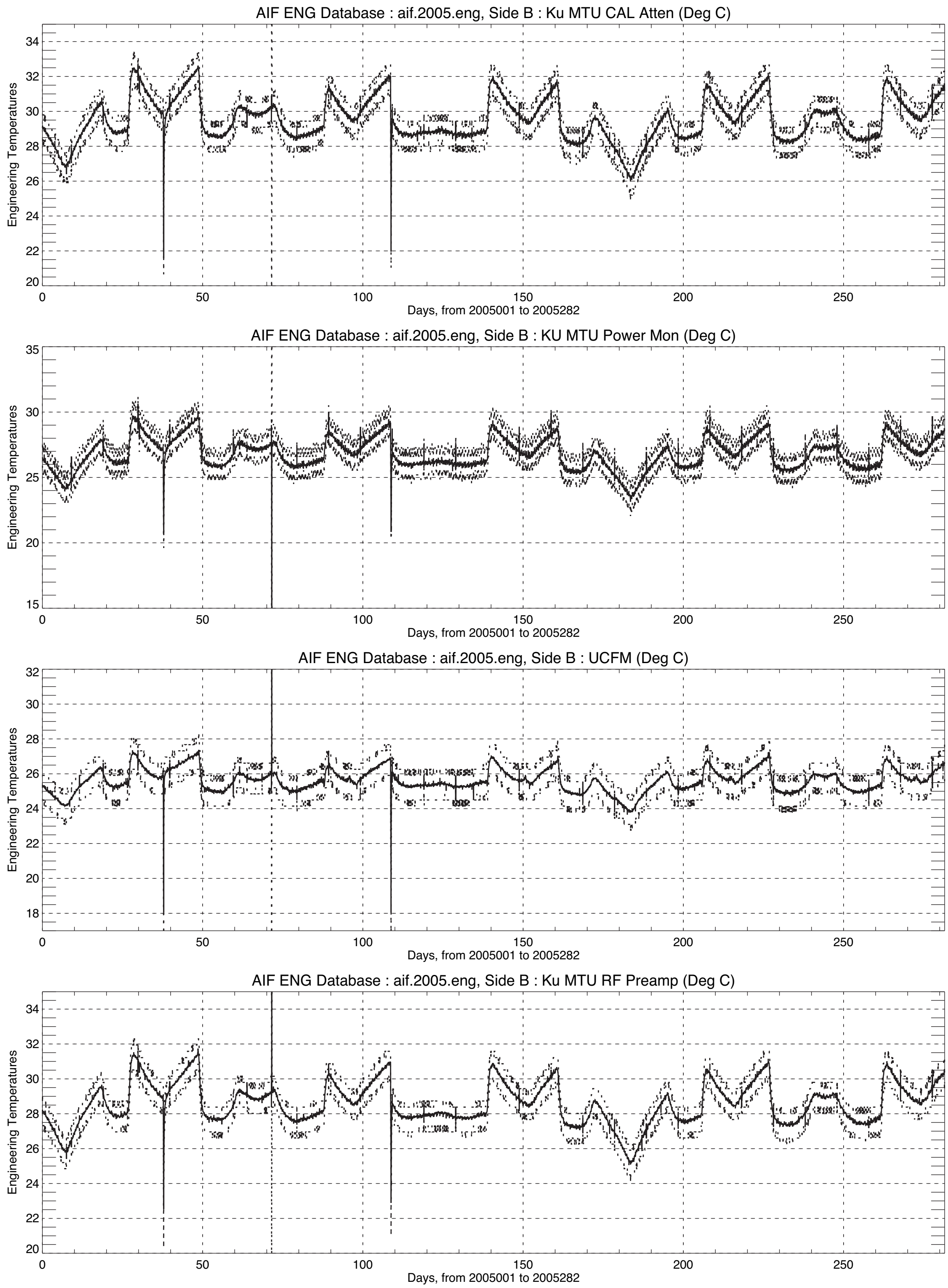
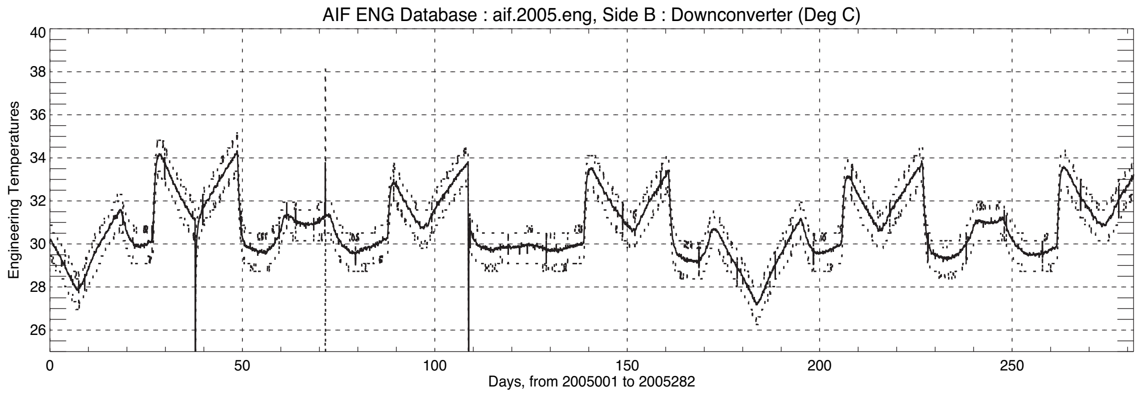
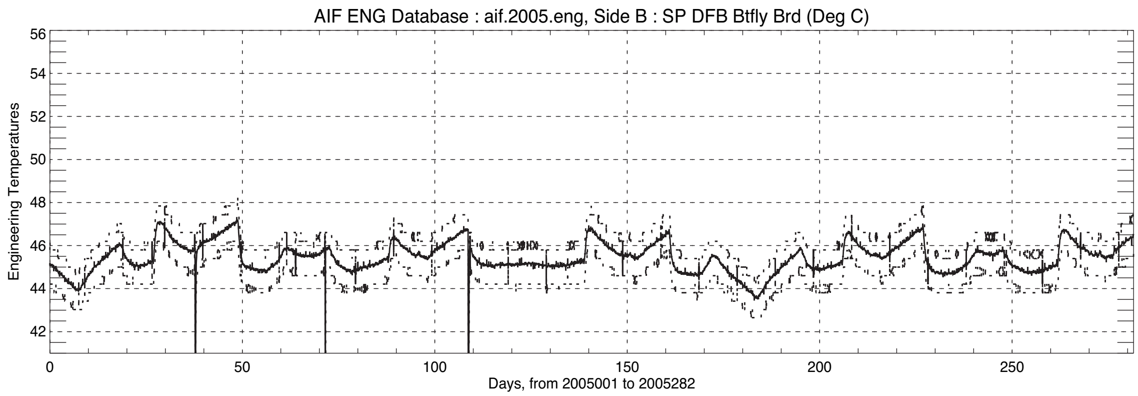
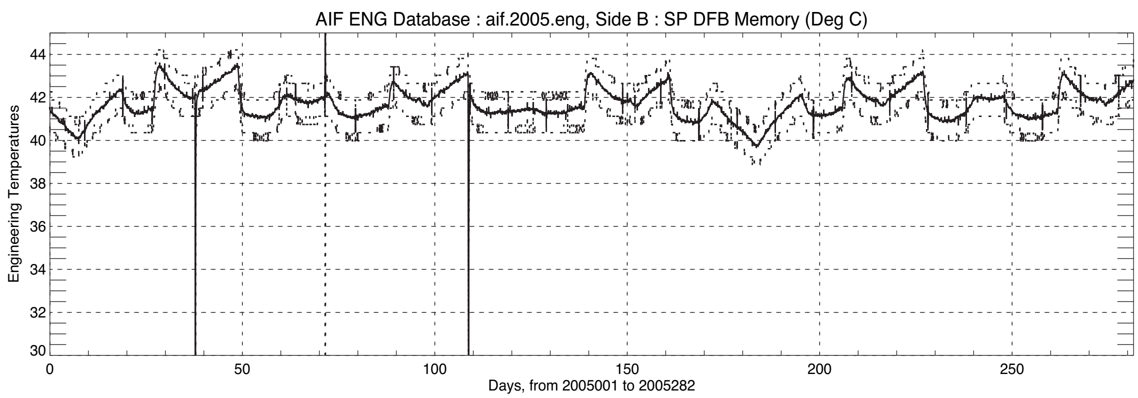


Figure D-1 Engineering Monitor Results for 2005 (Continued)







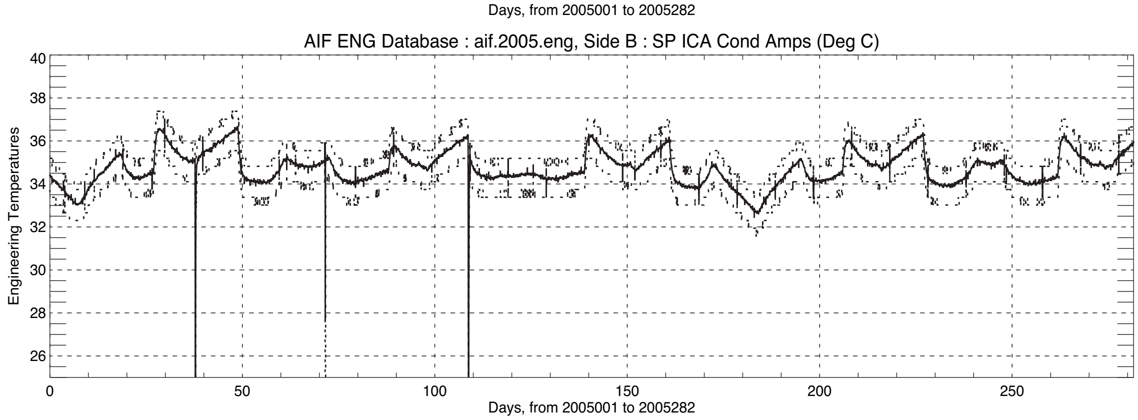


Figure D-1 Engineering Monitor Results for 2005 (Continued)

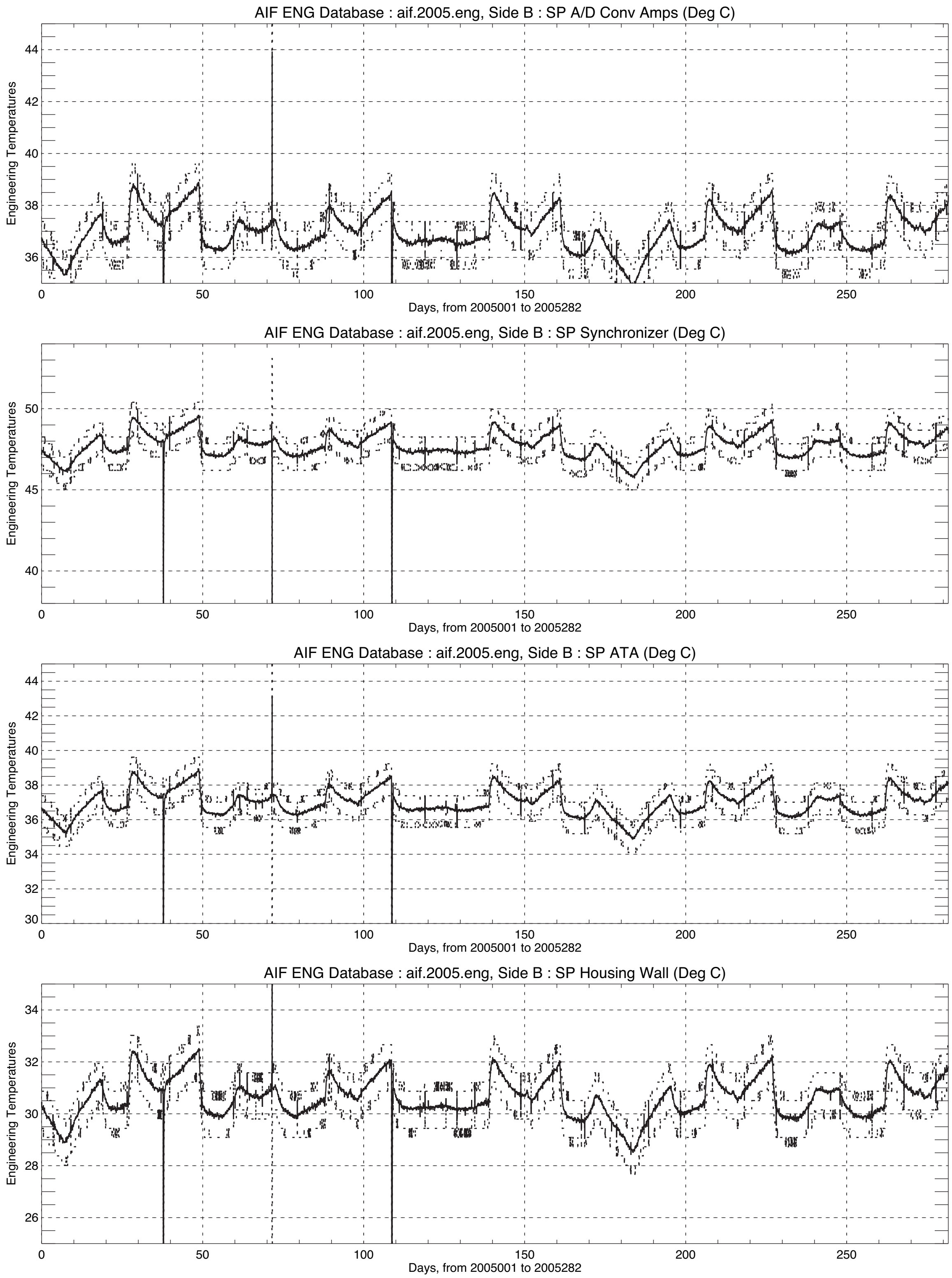


Figure D-1 Engineering Monitor Results for 2005 (Continued)

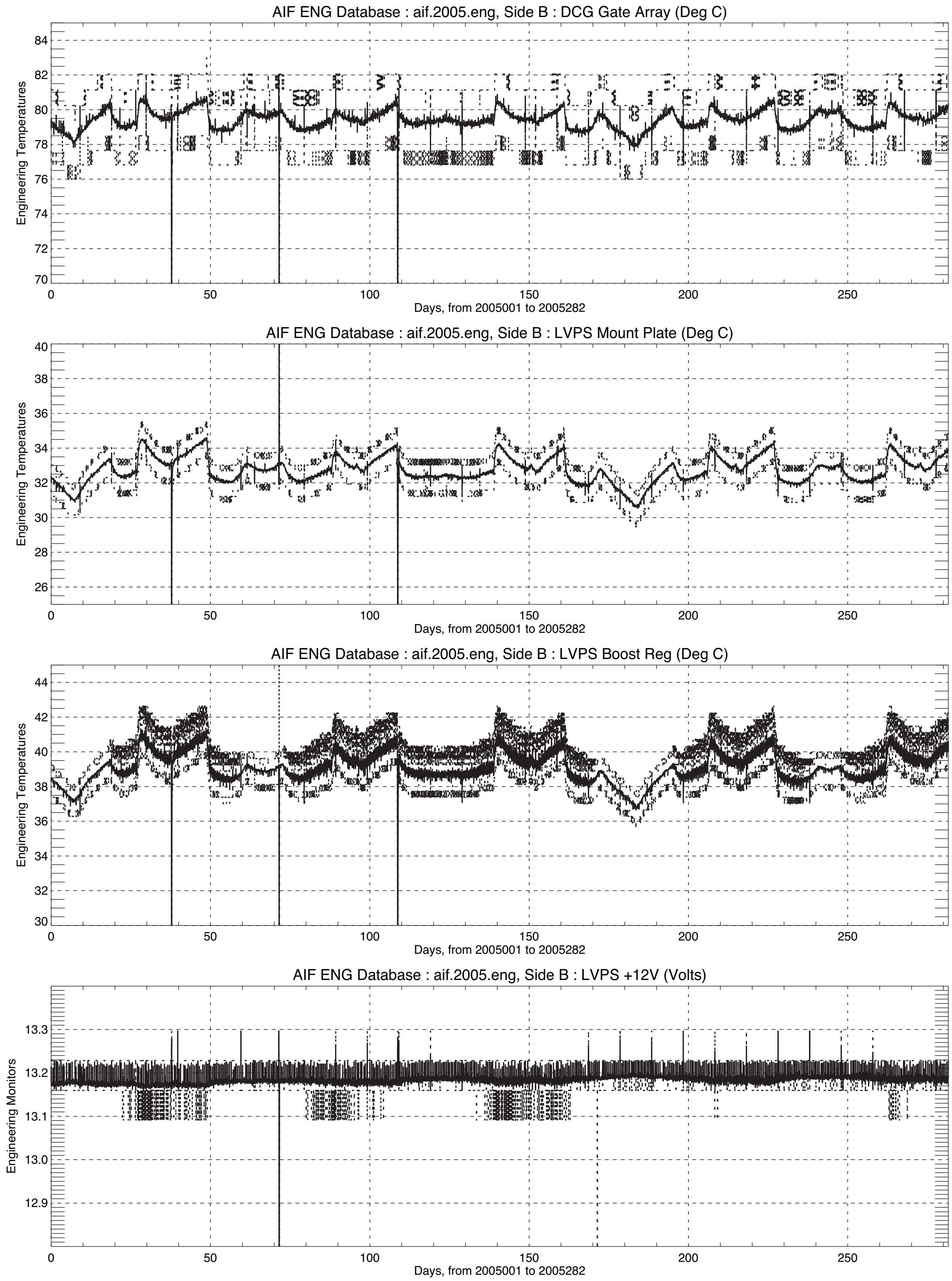


Figure D-1 Engineering Monitor Results for 2005 (Continued)

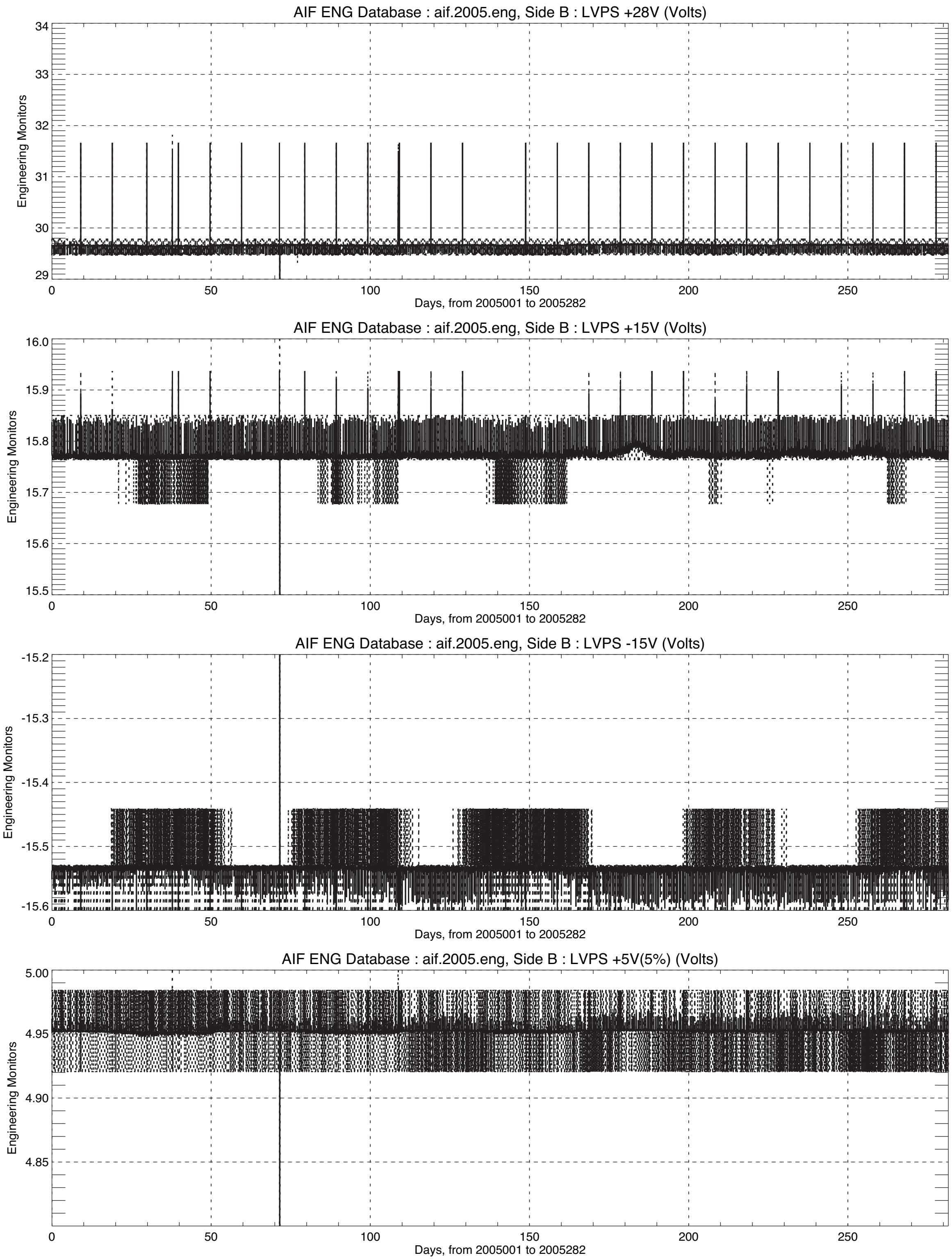


Figure D-1 Engineering Monitor Results for 2005 (Continued)

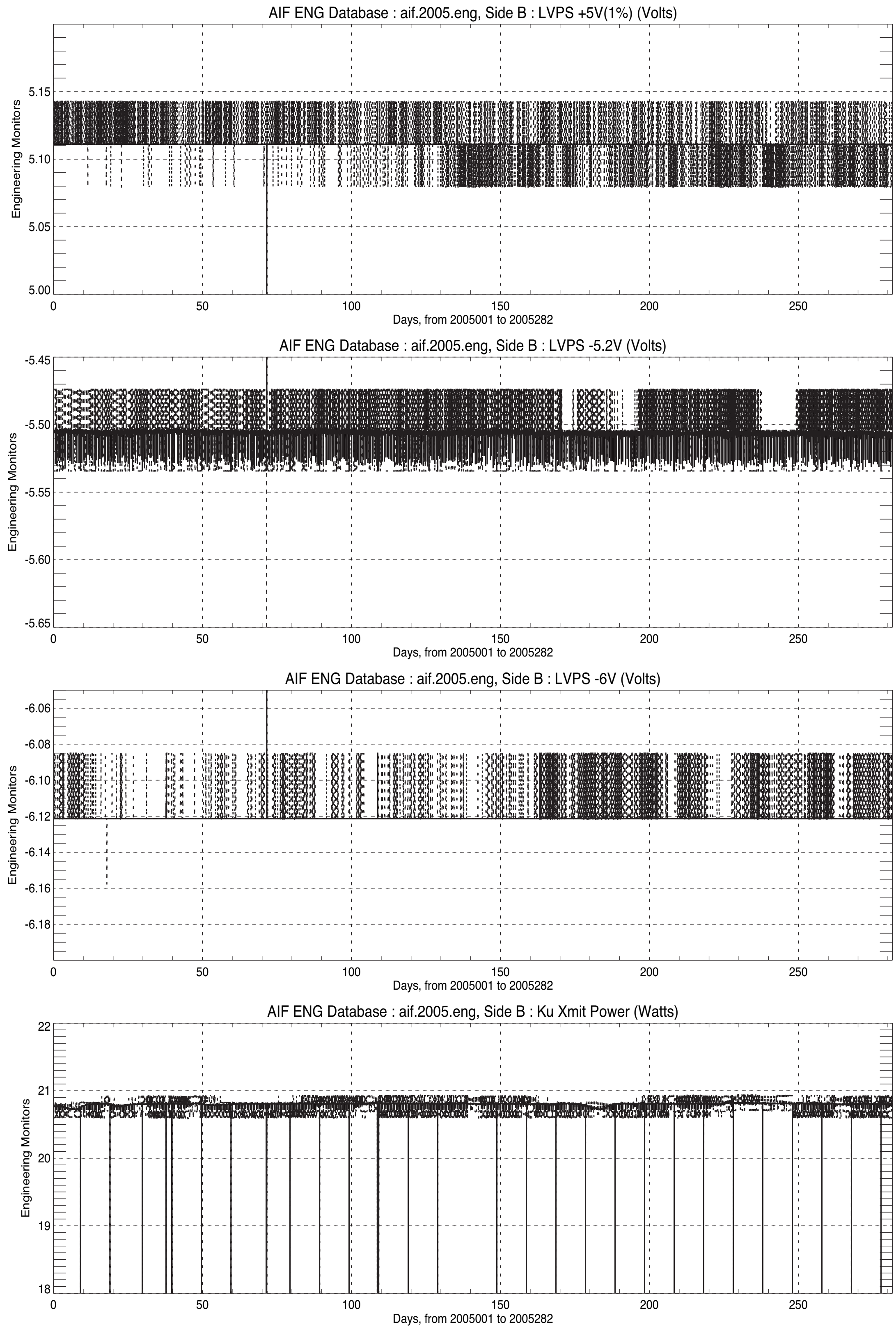


Figure D-1 Engineering Monitor Results for 2005 (Continued)

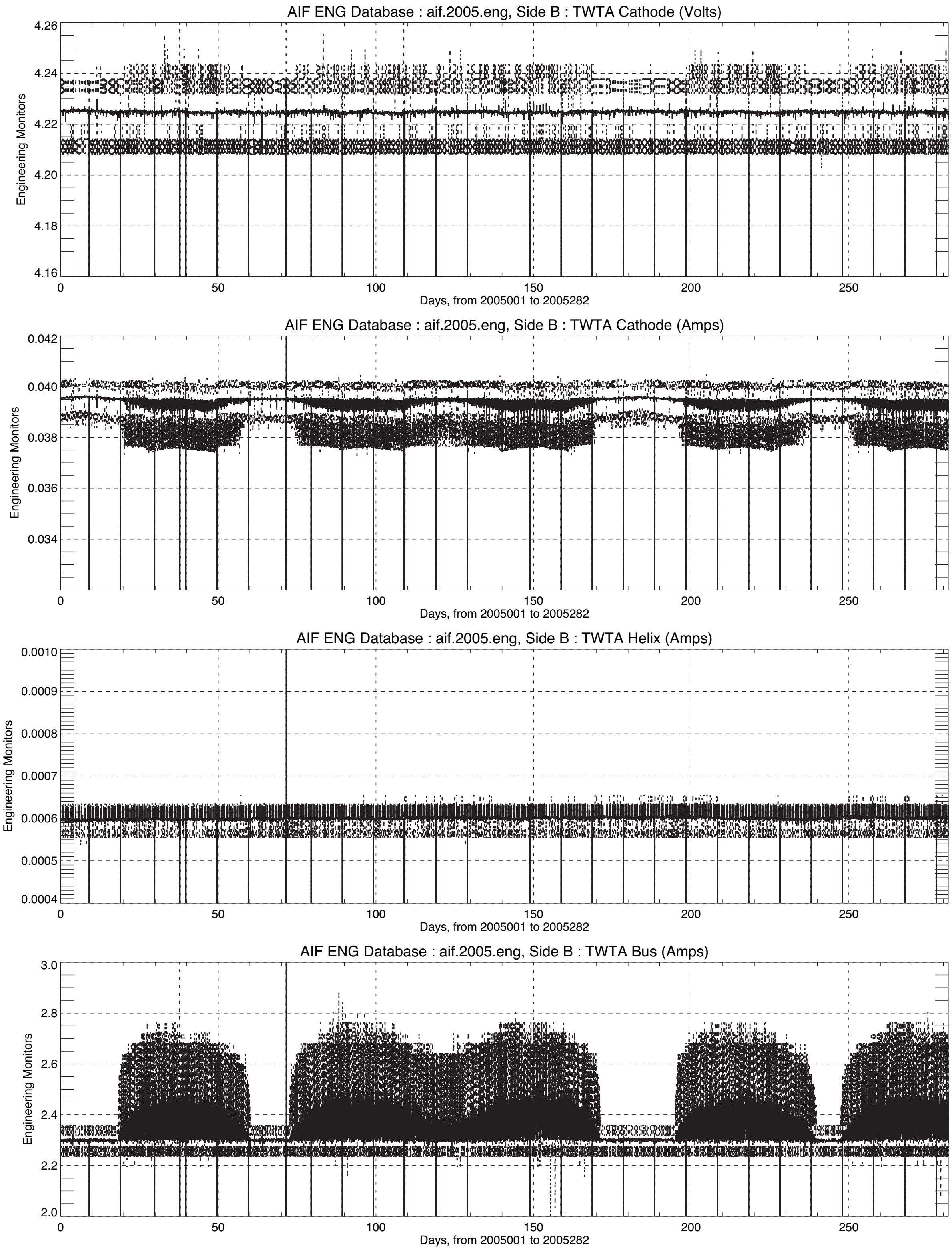


Figure D-1 Engineering Monitor Results for 2005 (Continued)

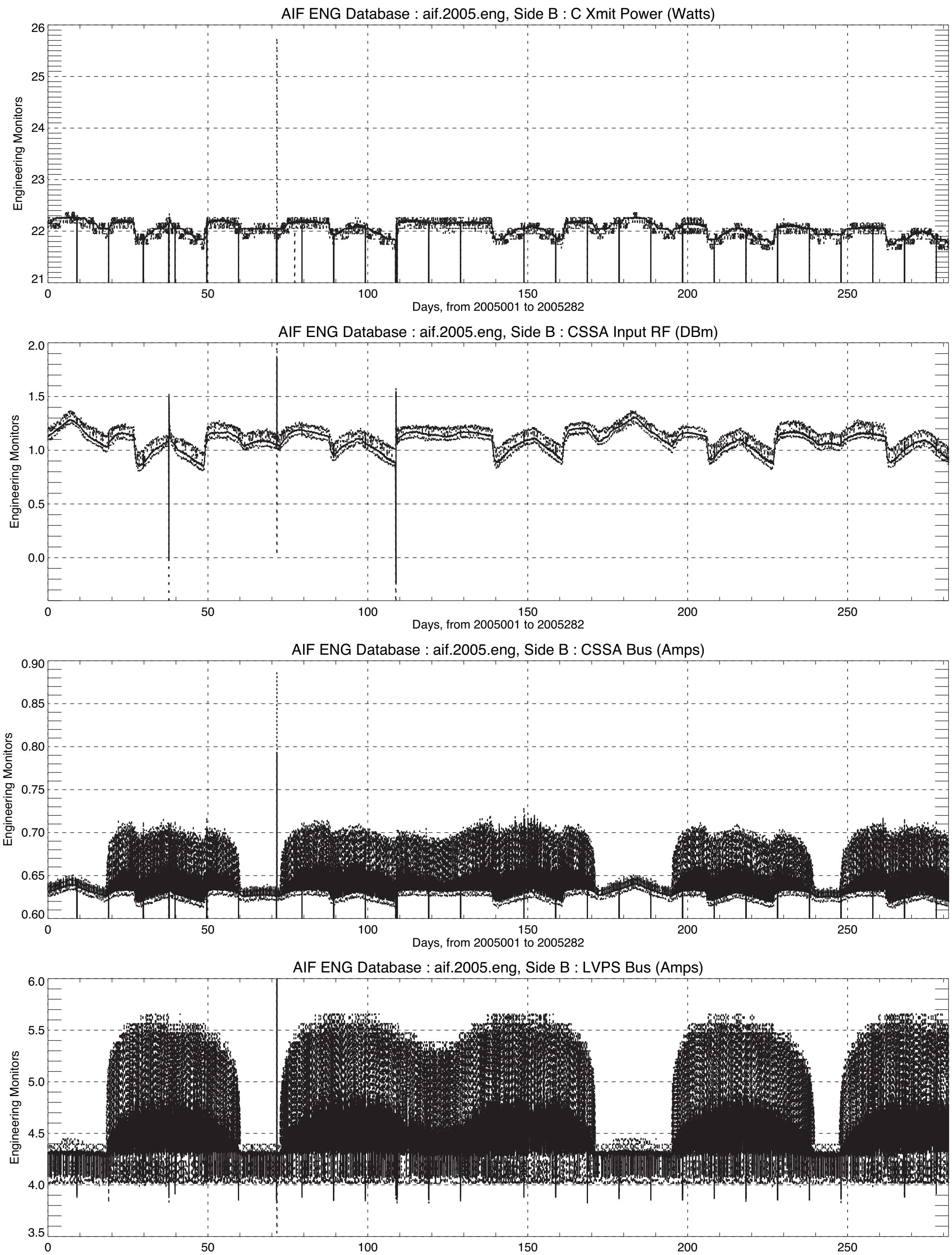


Figure D-1 Engineering Monitor Results for 2005 (Continued)

Appendix E
Internal Range Calibrations for 2005

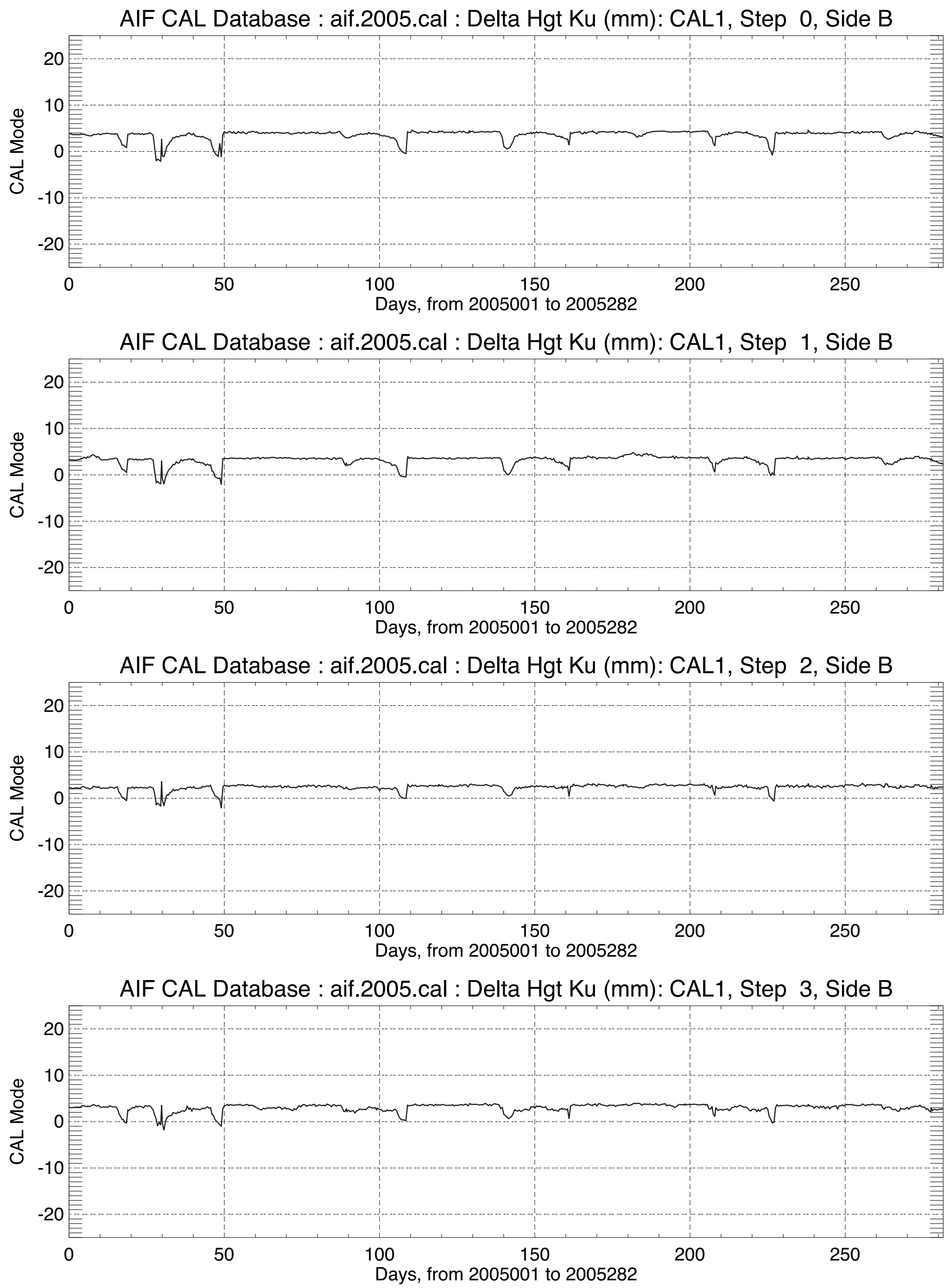


Figure E-1 Ku-Band Delta Range CAL1, 2005

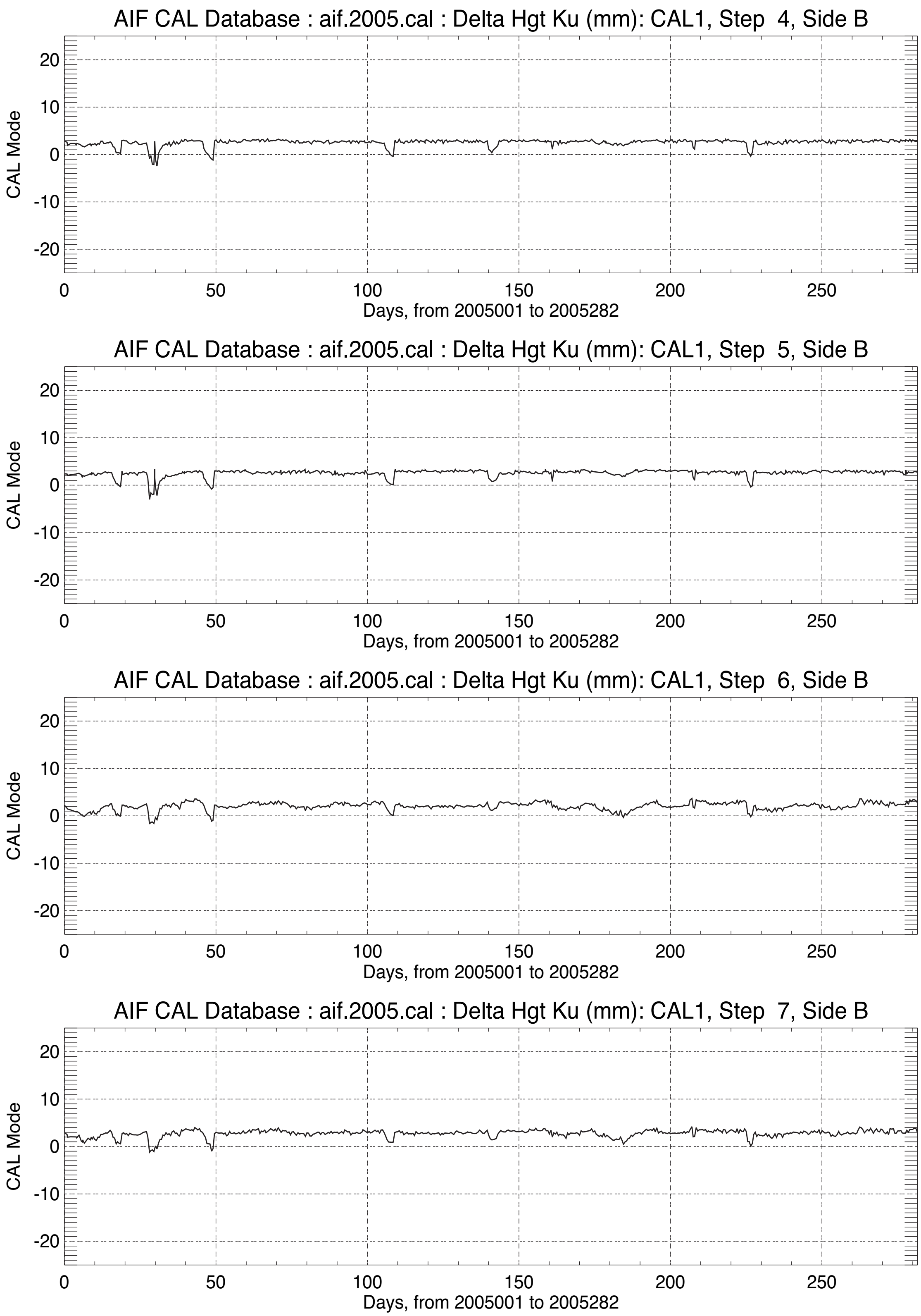


Figure E-1 Ku-Band Delta Range CAL1, 2005

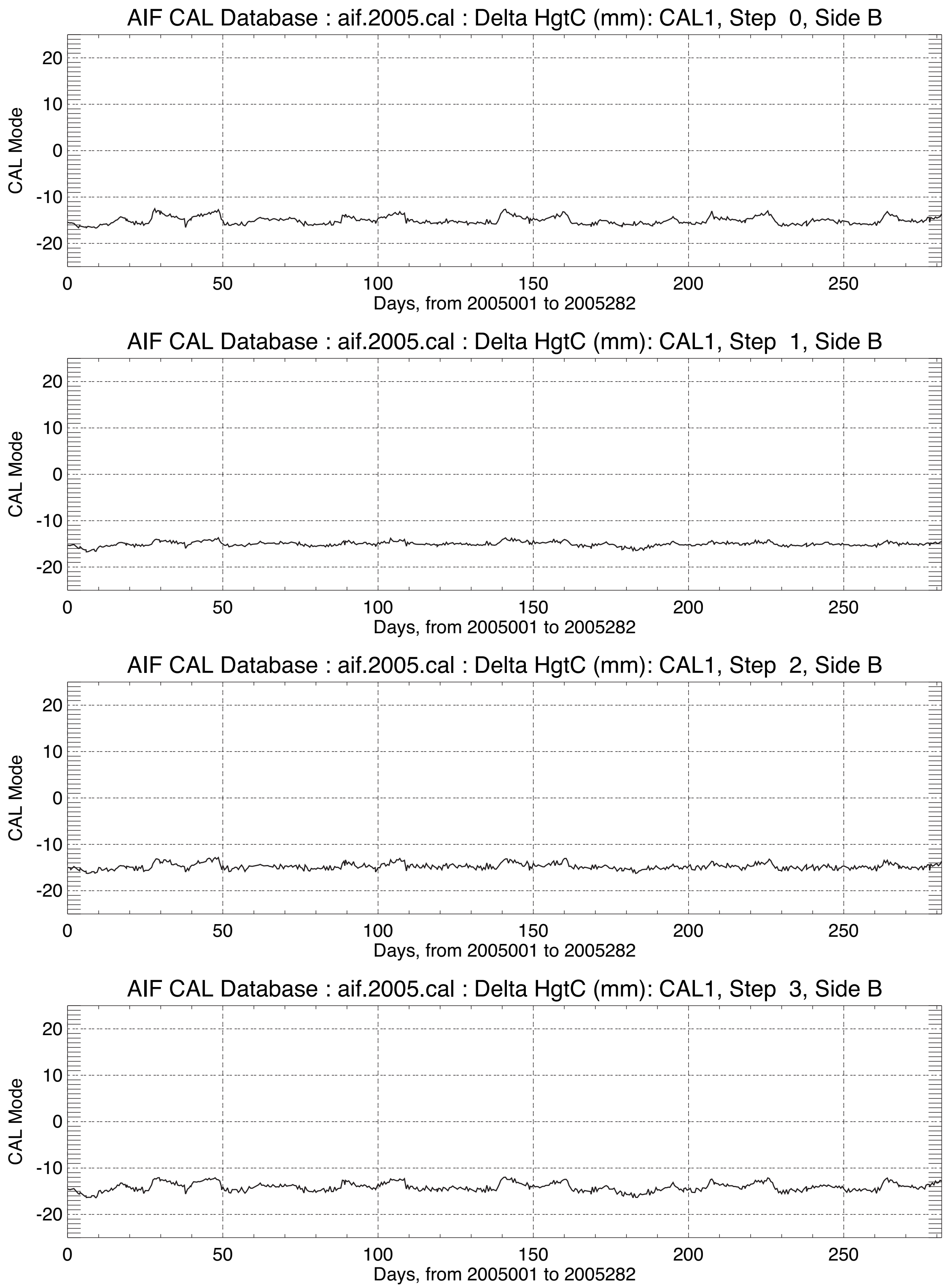


Figure E-2 C-Band Delta Range CAL1, 2005

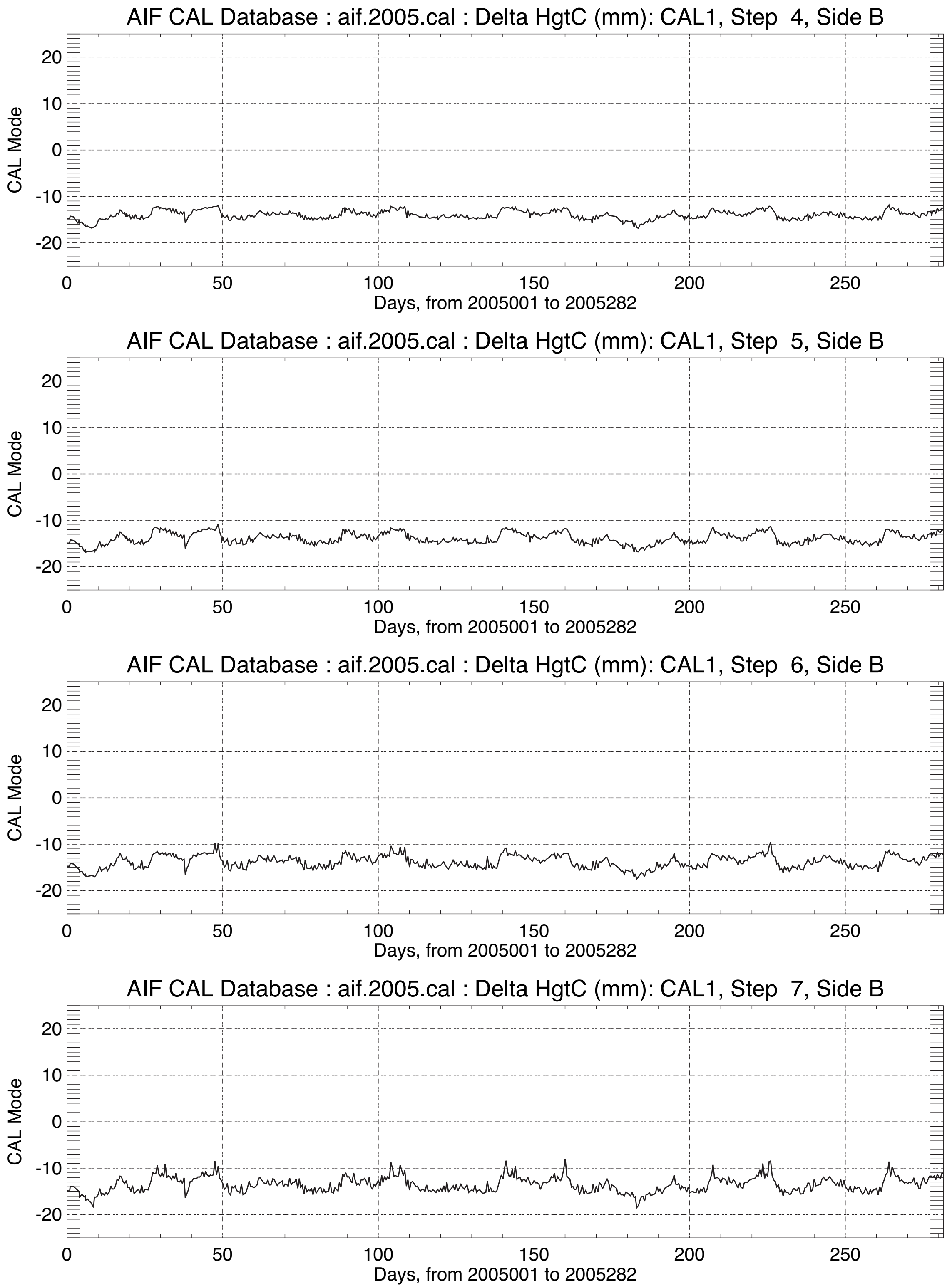


Figure E-2 C-Band Delta Range CAL1, 2005 (Continued)

Appendix F

AGC Calibrations for 2005

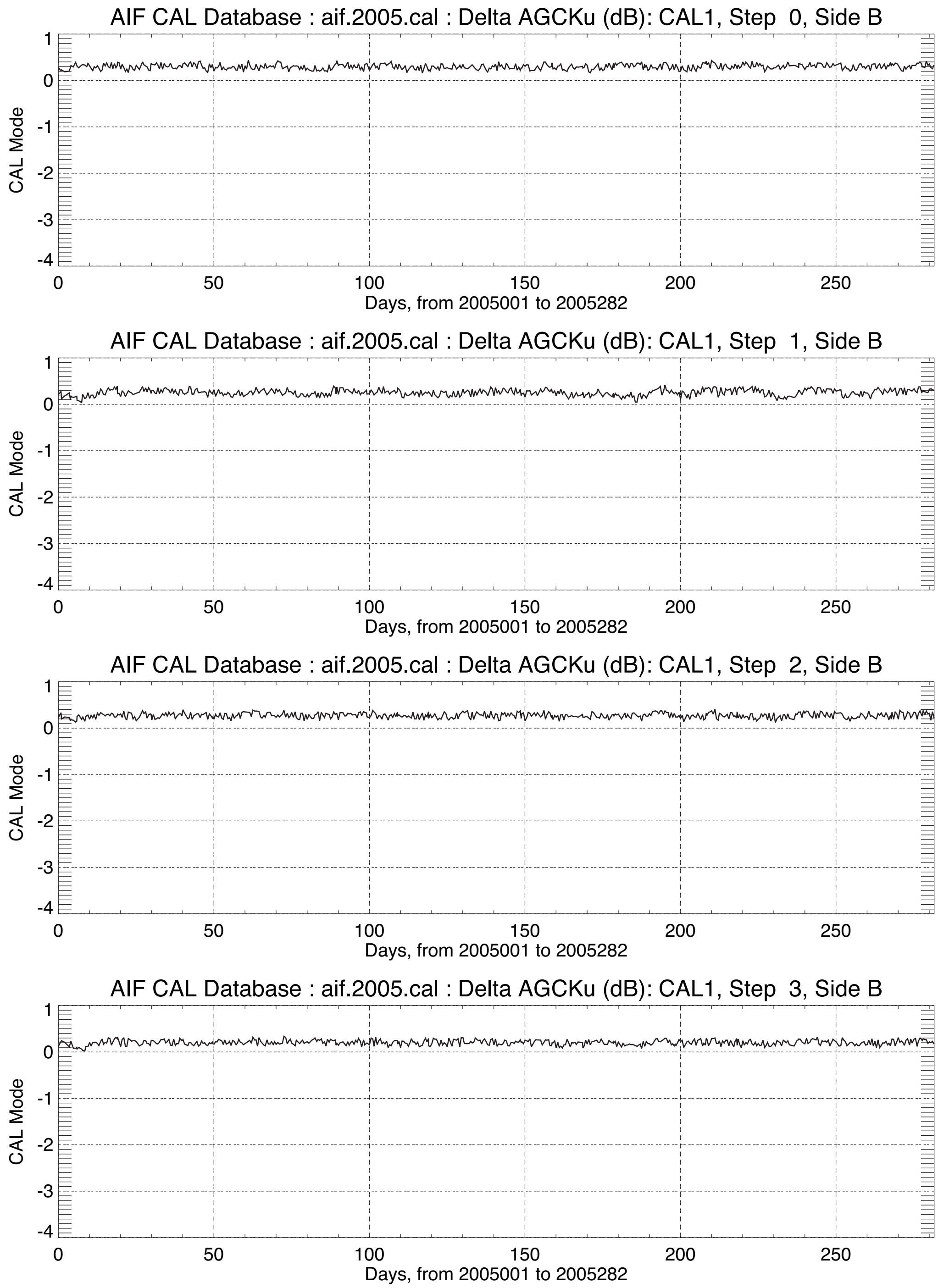


Figure F-1 Ku-Band Delta AGC CAL1 and CAL2, 2005

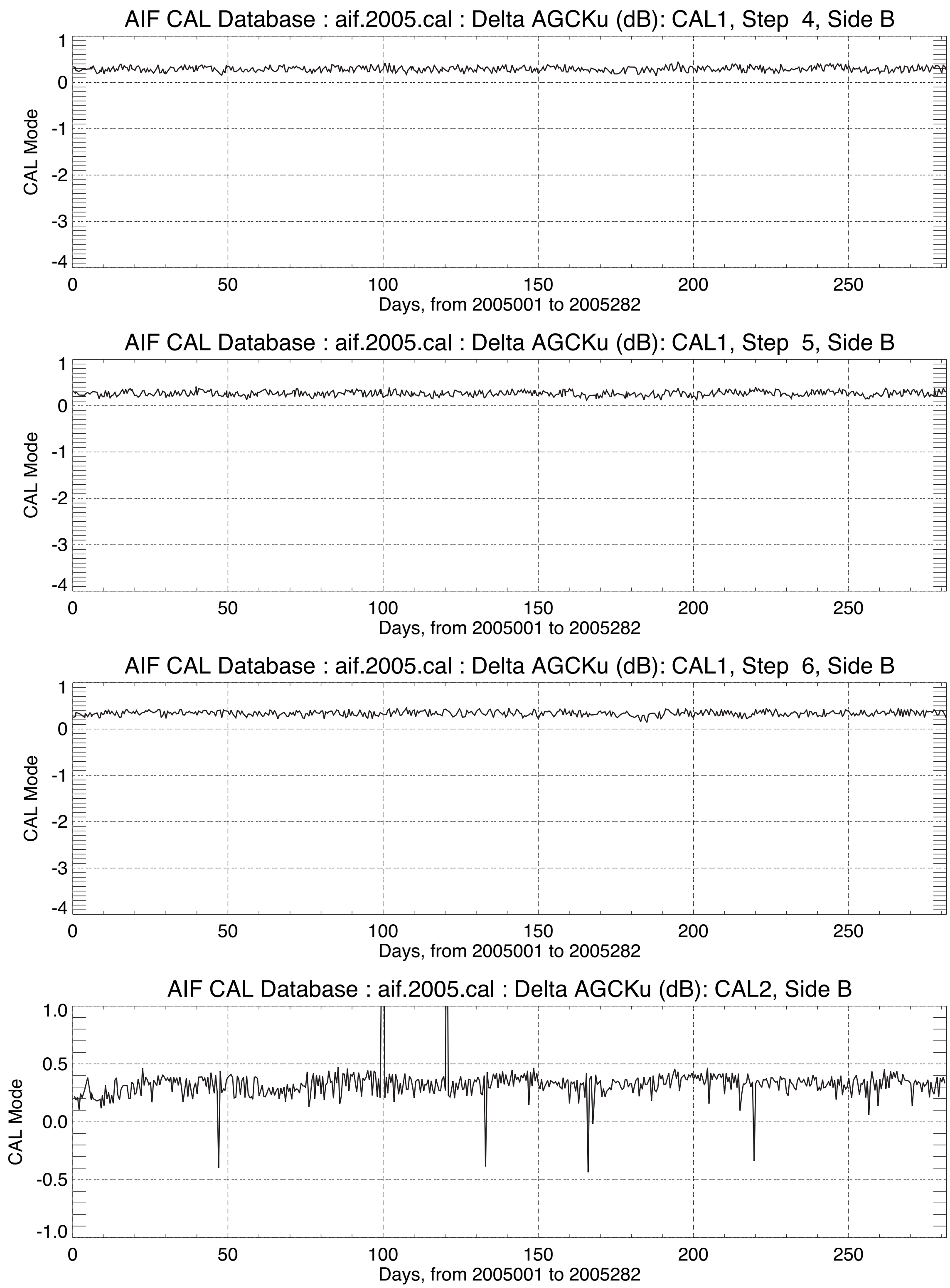


Figure F-1 Ku-Band Delta AGC CAL1 and CAL2, 2005 (Continued)

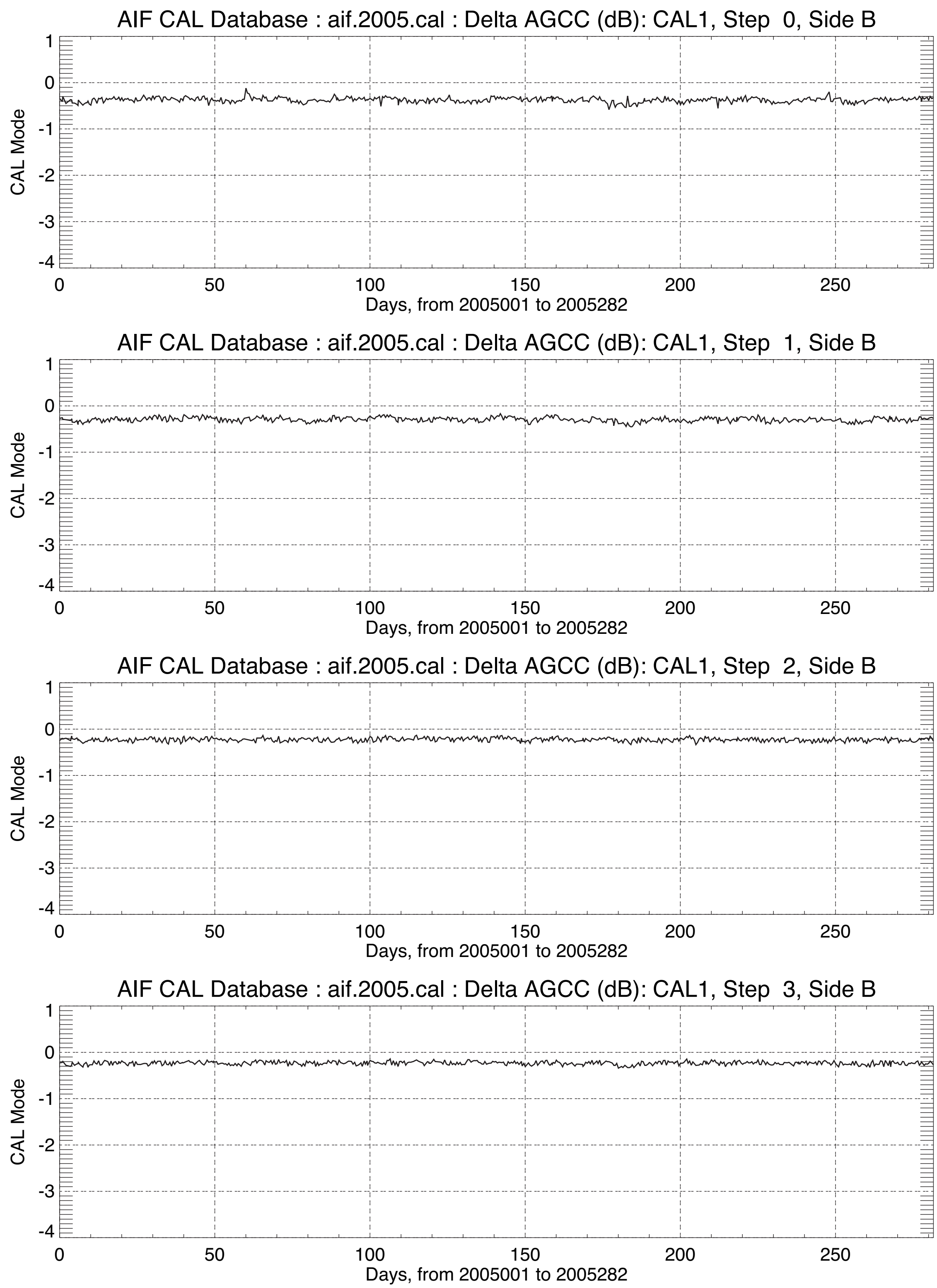


Figure F-2 C-Band Delta AGC CAL1 and CAL2, 2005

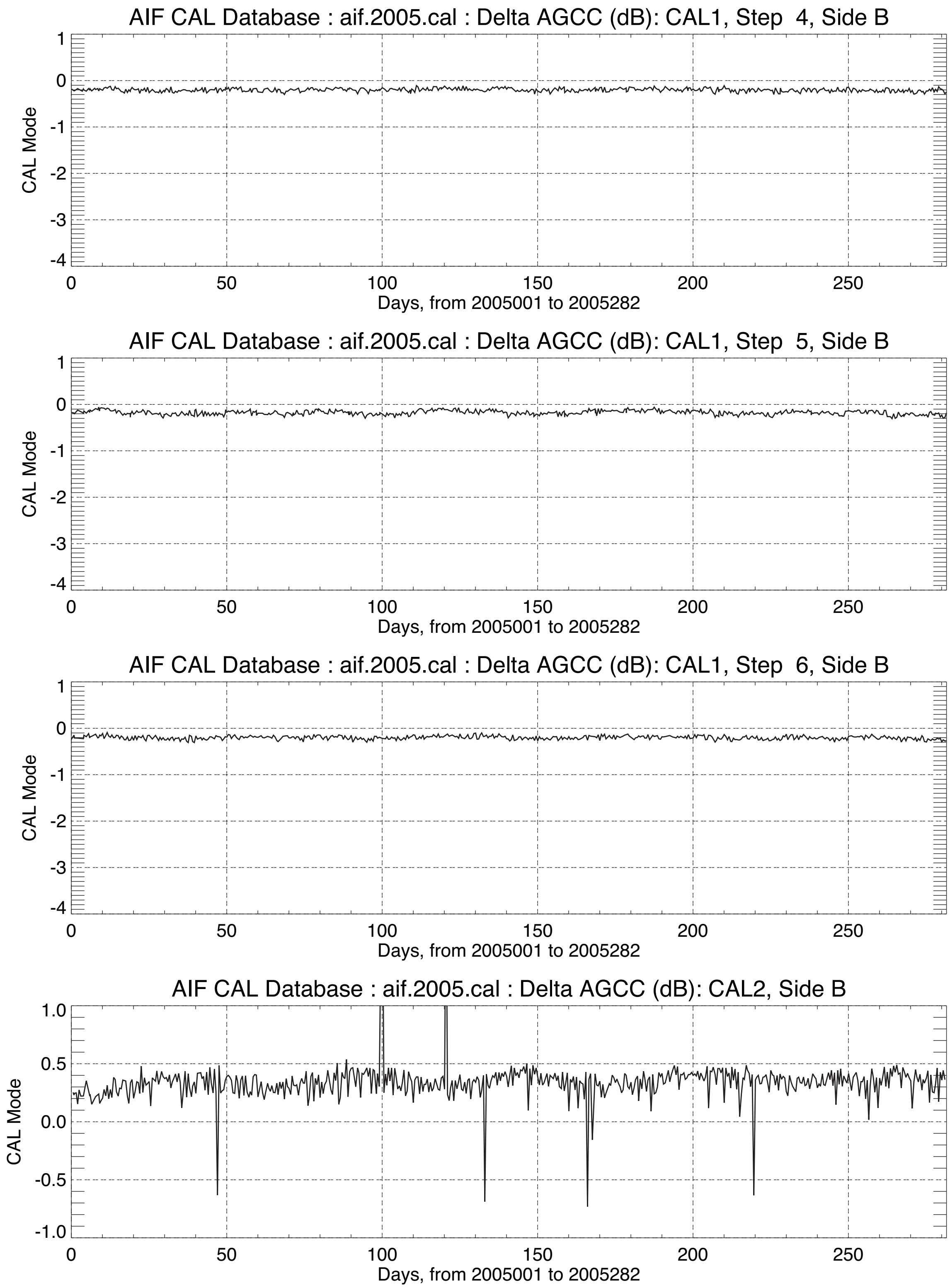


Figure F-2 C-Band Delta AGC CAL1 and CAL2, 2005

Appendix G
TOPEX Side B Sigma0 Cal

Table G-1 TOPEX Side B Sigma0 Cal

	Cal Table Values Used in Already-Distributed GDRs		New Cal Table Values from Sigma0 Trend Fit		Delta Cal Table Values, to be Added to Already-Distributed GDR Sigma0	
Data Cycle	Ku-band, dB	C-Band, dB	Ku-band, dB	C-Band, dB	Ku-band, dB	C-Band, dB
236	+0.45	+0.55	+0.451	+0.526	+0.001	-0.024
237	+0.45	+0.55	+0.450	+0.532	+0.000	-0.018
238	+0.45	+0.55	+0.450	+0.538	+0.000	-0.012
239	+0.45	+0.55	+0.450	+0.544	+0.000	-0.006
240	+0.45	+0.55	+0.450	+0.550	+0.000	+0.000
241	+0.45	+0.55	+0.450	+0.556	-0.000	+0.006
242	+0.45	+0.55	+0.450	+0.562	-0.000	+0.012
244	+0.45	+0.55	+0.449	+0.574	-0.001	+0.024
245	+0.45	+0.55	+0.449	+0.581	-0.001	+0.031
246	+0.45	+0.55	+0.449	+0.587	-0.001	+0.037
247	+0.45	+0.55	+0.449	+0.593	-0.001	+0.043
248	+0.45	+0.61	+0.449	+0.599	-0.001	-0.011
249	+0.45	+0.61	+0.449	+0.605	-0.001	-0.005
250	+0.45	+0.61	+0.449	+0.611	-0.001	+0.001
251	+0.45	+0.61	+0.448	+0.617	-0.002	+0.007
252	+0.45	+0.61	+0.448	+0.623	-0.002	+0.013
253	+0.45	+0.64	+0.448	+0.629	-0.002	-0.011
254	+0.45	+0.64	+0.448	+0.636	-0.002	-0.004
255	+0.45	+0.64	+0.448	+0.642	-0.002	+0.002
256	no cycle average in 256 because of safe hold during most of the cycle					
257	+0.45	+0.64	+0.349	+0.635	-0.101	-0.005

Table G-1 TOPEX Side B Sigma0 Cal

	Cal Table Values Used in Already-Distributed GDRs		New Cal Table Values from Sigma0 Trend Fit		Delta Cal Table Values, to be Added to Already-Distributed GDR Sigma0	
258	+0.45	+0.64	+0.340	+0.635	-0.110	-0.005
259	+0.27	+0.64	+0.331	+0.636	+0.061	-0.004
260	+0.27	+0.64	+0.321	+0.637	+0.051	-0.003
261	+0.27	+0.64	+0.312	+0.638	+0.042	-0.002
262	+0.24	+0.64	+0.302	+0.639	+0.062	-0.001
263	+0.24	+0.67	+0.293	+0.639	+0.053	-0.031
264	+0.24	+0.67	+0.284	+0.640	+0.044	-0.030
265	+0.24	+0.67	+0.274	+0.641	+0.034	-0.029
267	+0.21	+0.67	+0.255	+0.643	+0.045	-0.027
268	+0.21	+0.67	+0.246	+0.643	+0.036	-0.027
269	+0.21	+0.67	+0.236	+0.644	+0.026	-0.026
270	+0.18	+0.70	+0.237	+0.645	+0.057	-0.055
271	+0.18	+0.70	+0.238	+0.646	+0.058	-0.054
272	+0.18	+0.70	+0.239	+0.647	+0.059	-0.053
273	+0.18	+0.70	+0.240	+0.647	+0.060	-0.053
274	+0.15	+0.70	+0.241	+0.648	+0.091	-0.052
275	+0.15	+0.70	+0.242	+0.649	+0.092	-0.051
276	+0.15	+0.70	+0.243	+0.650	+0.093	-0.050
277	+0.21	+0.58	+0.244	+0.651	+0.034	+0.071
279	+0.21	+0.58	+0.245	+0.652	+0.035	+0.072
280	+0.21	+0.58	+0.246	+0.653	+0.036	+0.073
281	+0.21	+0.58	+0.247	+0.654	+0.037	+0.074
282	+0.21	+0.58	+0.248	+0.654	+0.038	+0.074
283	+0.21	+0.61	+0.249	+0.655	+0.039	+0.045
284	+0.21	+0.61	+0.250	+0.656	+0.040	+0.046

Table G-1 TOPEX Side B Sigma0 Cal

	Cal Table Values Used in Already-Distributed GDRs		New Cal Table Values from Sigma0 Trend Fit		Delta Cal Table Values, to be Added to Already-Distributed GDR Sigma0	
285	+0.21	+0.61	+0.251	+0.657	+0.041	+0.047
286	+0.21	+0.61	+0.251	+0.658	+0.041	+0.048
287	+0.21	+0.61	+0.252	+0.658	+0.042	+0.048
288	+0.21	+0.61	+0.253	+0.659	+0.043	+0.049
290	+0.18	+0.61	+0.255	+0.661	+0.075	+0.051
291	+0.18	+0.61	+0.256	+0.662	+0.076	+0.052
292	+0.18	+0.61	+0.257	+0.662	+0.077	+0.052
293	+0.18	+0.61	+0.258	+0.663	+0.078	+0.053
294	+0.18	+0.61	+0.259	+0.664	+0.079	+0.054
295	+0.18	+0.61	+0.259	+0.665	+0.079	+0.055
296	+0.18	+0.61	+0.260	+0.666	+0.080	+0.056
297	+0.18	+0.61	+0.261	+0.666	+0.081	+0.056
298	+0.18	+0.61	+0.262	+0.667	+0.082	+0.057
300	+0.24	+0.61	+0.264	+0.669	+0.024	+0.059
301	+0.24	+0.61	+0.265	+0.670	+0.025	+0.060
302	+0.24	+0.61	+0.266	+0.670	+0.026	+0.060
303	+0.24	+0.61	+0.266	+0.671	+0.026	+0.061
304	+0.24	+0.61	+0.267	+0.672	+0.027	+0.062
305	+0.24	+0.64	+0.268	+0.673	+0.028	+0.033
306	+0.24	+0.64	+0.269	+0.676	+0.029	+0.036
308	+0.24	+0.64	+0.271	+0.684	+0.031	+0.044
309	+0.24	+0.64	+0.272	+0.687	+0.032	+0.047
310	+0.24	+0.64	+0.273	+0.691	+0.033	+0.051
311	+0.24	+0.64	+0.274	+0.695	+0.034	+0.055
312	+0.24	+0.64	+0.274	+0.698	+0.034	+0.058

Table G-1 TOPEX Side B Sigma0 Cal

	Cal Table Values Used in Already-Distributed GDRs		New Cal Table Values from Sigma0 Trend Fit		Delta Cal Table Values, to be Added to Already-Distributed GDR Sigma0	
313	+0.24	+0.64	+0.275	+0.702	+0.035	+0.062
314	+0.24	+0.64	+0.276	+0.705	+0.036	+0.065
315	+0.24	+0.64	+0.277	+0.709	+0.037	+0.069
316	+0.24	+0.64	+0.278	+0.713	+0.038	+0.073
317	+0.24	+0.64	+0.279	+0.716	+0.039	+0.076
318	+0.24	+0.64	+0.280	+0.720	+0.040	+0.080
319	+0.24	+0.64	+0.281	+0.723	+0.041	+0.083
320	+0.24	+0.64	+0.281	+0.727	+0.041	+0.087
321	+0.24	+0.64	+0.282	+0.731	+0.042	+0.091
322	+0.24	+0.64	+0.283	+0.734	+0.043	+0.094
323	+0.24	+0.64	+0.284	+0.738	+0.044	+0.098
324	+0.24	+0.64	+0.285	+0.741	+0.045	+0.101
325	+0.24	+0.64	+0.286	+0.745	+0.046	+0.105
326	+0.24	+0.64	+0.287	+0.749	+0.047	+0.109
327	+0.27	+0.76	+0.288	+0.752	+0.018	-0.008
328	+0.27	+0.76	+0.289	+0.756	+0.019	-0.004
329	+0.27	+0.76	+0.289	+0.760	+0.019	-0.000
330	+0.27	+0.76	+0.290	+0.763	+0.020	+0.003
331	+0.27	+0.76	+0.291	+0.767	+0.021	+0.007
332	+0.27	+0.76	+0.292	+0.770	+0.022	+0.010
333	+0.27	+0.76	+0.293	+0.774	+0.023	+0.014
334	+0.27	+0.76	+0.294	+0.774	+0.024	+0.014
335	+0.27	+0.76	+0.295	+0.775	+0.025	+0.015
336	+0.27	+0.76	+0.296	+0.775	+0.026	+0.015
337	+0.30	+0.76	+0.296	+0.776	-0.004	+0.016

Table G-1 TOPEX Side B Sigma0 Cal

	Cal Table Values Used in Already-Distributed GDRs		New Cal Table Values from Sigma0 Trend Fit		Delta Cal Table Values, to be Added to Already-Distributed GDR Sigma0	
338	+0.30	+0.79	+0.297	+0.776	-0.003	-0.014
339	+0.30	+0.79	+0.298	+0.776	-0.002	-0.014
340	+0.30	+0.79	+0.298	+0.777	-0.002	-0.013
341	+0.30	+0.79	+0.298	+0.777	-0.002	-0.013
342	+0.30	+0.79	+0.298	+0.778	-0.002	-0.012
343	+0.30	+0.79	+0.298	+0.778	-0.002	-0.012
344	+0.30	+0.79	+0.298	+0.778	-0.002	-0.012
345	+0.30	+0.79	+0.298	+0.779	-0.002	-0.011
346	+0.30	+0.79	+0.298	+0.779	-0.002	-0.011
347	+0.30	+0.79	+0.298	+0.779	-0.002	-0.011
348	+0.30	+0.79	+0.298	+0.780	-0.002	-0.010
349	+0.30	+0.79	+0.298	+0.780	-0.002	-0.010
350	+0.30	+0.79	+0.298	+0.781	-0.002	-0.009
351	+0.30	+0.82	+0.298	+0.781	-0.002	-0.039
352	+0.30	+0.82	+0.298	+0.781	-0.002	-0.039
353	+0.30	+0.82	+0.298	+0.782	-0.002	-0.038
354	+0.30	+0.82	+0.298	+0.782	-0.002	-0.038
355	+0.30	+0.82	+0.298	+0.783	-0.002	-0.037
356	+0.30	+0.82	+0.298	+0.783	-0.002	-0.037
357	+0.30	+0.82	+0.298	+0.783	-0.002	-0.037
358	+0.33	+0.82	+0.298	+0.784	-0.032	-0.036
359	+0.33	+0.82	+0.298	+0.784	-0.032	-0.036
360	+0.33	+0.82	+0.298	+0.785	-0.032	-0.035
362	+0.33	+0.82	+0.298	+0.785	-0.032	-0.035
363	+0.33	+0.85	+0.298	+0.786	-0.032	-0.064

Table G-1 TOPEX Side B Sigma0 Cal

	Cal Table Values Used in Already-Distributed GDRs		New Cal Table Values from Sigma0 Trend Fit		Delta Cal Table Values, to be Added to Already-Distributed GDR Sigma0	
364	+0.33	+0.85	+0.298	+0.786	-0.032	-0.064
365	+0.33	+0.85	+0.298	+0.787	-0.032	-0.063
366	+0.33	+0.85	+0.298	+0.787	-0.032	-0.063
367	+0.33	+0.85	+0.298	+0.787	-0.032	-0.063
368	+0.33	+0.85	+0.298	+0.788	-0.032	-0.062
369	+0.33	+0.85	+0.298	+0.788	-0.032	-0.062
370	+0.33	+0.85	+0.298	+0.789	-0.032	-0.061
371	+0.33	+0.85	+0.298	+0.789	-0.032	-0.061
372	+0.33	+0.85	+0.298	+0.789	-0.032	-0.061
373	+0.33	+0.85	+0.298	+0.790	-0.032	-0.060
374	+0.33	+0.85	+0.298	+0.790	-0.032	-0.060
375	+0.33	+0.85	+0.298	+0.790	-0.032	-0.060
376	+0.33	+0.85	+0.298	+0.792	-0.032	-0.058
377	+0.33	+0.85	+0.298	+0.793	-0.032	-0.057
378	+0.33	+0.85	+0.298	+0.795	-0.032	-0.055
379	+0.33	+0.85	+0.298	+0.796	-0.032	-0.054
380	+0.33	+0.85	+0.299	+0.798	-0.031	-0.052
381	+0.33	+0.85	+0.299	+0.799	-0.031	-0.051
382	+0.33	+0.85	+0.299	+0.801	-0.031	-0.049
383	+0.33	+0.85	+0.299	+0.802	-0.031	-0.048
384	+0.33	+0.85	+0.300	+0.804	-0.030	-0.046
385	+0.33	+0.85	+0.300	+0.805	-0.030	-0.045
386	+0.33	+0.85	+0.300	+0.807	-0.030	-0.043
387	+0.33	+0.85	+0.300	+0.808	-0.030	-0.042
388	+0.33	+0.85	+0.300	+0.810	-0.030	-0.040

Table G-1 TOPEX Side B Sigma0 Cal

	Cal Table Values Used in Already-Distributed GDRs		New Cal Table Values from Sigma0 Trend Fit		Delta Cal Table Values, to be Added to Already-Distributed GDR Sigma0	
389	+0.33	+0.85	+0.301	+0.811	-0.029	-0.039
390	+0.33	+0.85	+0.301	+0.813	-0.029	-0.037
391	+0.33	+0.85	+0.301	+0.814	-0.029	-0.036
392	+0.33	+0.85	+0.301	+0.816	-0.029	-0.034
393	+0.33	+0.85	+0.302	+0.817	-0.028	-0.033
394	+0.33	+0.85	+0.302	+0.819	-0.028	-0.031
395	+0.33	+0.85	+0.302	+0.820	-0.028	-0.030
396	+0.33	+0.85	+0.302	+0.822	-0.028	-0.028
397	+0.33	+0.85	+0.303	+0.823	-0.027	-0.027
398	+0.33	+0.85	+0.303	+0.825	-0.027	-0.025
399	+0.33	+0.85	+0.303	+0.826	-0.027	-0.024
400	+0.33	+0.85	+0.303	+0.828	-0.027	-0.022
401	+0.33	+0.85	+0.303	+0.829	-0.027	-0.021
402	+0.33	+0.85	+0.304	+0.831	-0.026	-0.019
403	+0.33	+0.85	+0.304	+0.832	-0.026	-0.018
404	+0.33	+0.85	+0.304	+0.834	-0.026	-0.016
405	+0.33	+0.85	+0.304	+0.835	-0.026	-0.015
406	+0.33	+0.85	+0.305	+0.837	-0.025	-0.013
407	+0.33	+0.85	+0.305	+0.838	-0.025	-0.012
408	+0.33	+0.85	+0.305	+0.840	-0.025	-0.010
409	+0.33	+0.85	+0.305	+0.841	-0.025	-0.009
410	+0.33	+0.85	+0.305	+0.843	-0.025	-0.007
411	+0.33	+0.85	+0.306	+0.844	-0.024	-0.006
412	+0.33	+0.85	+0.306	+0.846	-0.024	-0.004
413	+0.33	+0.85	+0.306	+0.847	-0.024	-0.003

Table G-1 TOPEX Side B Sigma0 Cal

	Cal Table Values Used in Already-Distributed GDRs		New Cal Table Values from Sigma0 Trend Fit		Delta Cal Table Values, to be Added to Already-Distributed GDR Sigma0	
414	+0.33	+0.85	+0.306	+0.849	-0.024	-0.001
415	+0.33	+0.85	+0.307	+0.850	-0.023	+0.000
416	+0.33	+0.85	+0.307	+0.852	-0.023	+0.002
417	+0.33	+0.85	+0.307	+0.853	-0.023	+0.003
418	+0.33	+0.85	+0.307	+0.855	-0.023	+0.005
419	+0.33	+0.85	+0.307	+0.856	-0.023	+0.006
420	+0.33	+0.85	+0.308	+0.858	-0.022	+0.008
422	+0.33	+0.85	+0.308	+0.861	-0.022	+0.011
423	+0.33	+0.85	+0.308	+0.862	-0.022	+0.012
424	+0.33	+0.85	+0.309	+0.864	-0.021	+0.014
425	+0.33	+0.85	+0.309	+0.865	-0.021	+0.015
426	+0.33	+0.85	+0.309	+0.867	-0.021	+0.017
427	+0.33	+0.85	+0.309	+0.868	-0.021	+0.018
428	+0.33	+0.85	+0.310	+0.870	-0.020	+0.020
429	+0.33	+0.85	+0.310	+0.871	-0.020	+0.021
430	+0.33	+0.85	+0.310	+0.873	-0.020	+0.023
433	+0.30	+0.88	+0.311	+0.877	+0.011	-0.003
434	+0.30	+0.88	+0.311	+0.879	+0.011	-0.001
435	+0.30	+0.88	+0.311	+0.880	+0.011	+0.000
436	+0.30	+0.88	+0.311	+0.882	+0.011	+0.002
437	+0.30	+0.88	+0.312	+0.883	+0.012	+0.003
438	+0.30	+0.88	+0.312	+0.885	+0.012	+0.005
439	+0.30	+0.88	+0.312	+0.886	+0.012	+0.006
440	+0.30	+0.88	+0.312	+0.888	+0.012	+0.008
441	+0.30	+0.91	+0.312	+0.889	+0.012	-0.021

Table G-1 TOPEX Side B Sigma0 Cal

	Cal Table Values Used in Already-Distributed GDRs		New Cal Table Values from Sigma0 Trend Fit		Delta Cal Table Values, to be Added to Already-Distributed GDR Sigma0	
442	+0.30	+0.91	+0.313	+0.891	+0.013	-0.019
443	+0.30	+0.91	+0.313	+0.892	+0.013	-0.018
444	+0.30	+0.91	+0.313	+0.894	+0.013	-0.016
445	+0.30	+0.91	+0.313	+0.895	+0.013	-0.015
446	+0.30	+0.91	+0.314	+0.897	+0.014	-0.013
447	+0.30	+0.91	+0.314	+0.898	+0.014	-0.012
448	+0.30	+0.91	+0.314	+0.900	+0.014	-0.010
449	+0.30	+0.91	+0.314	+0.901	+0.014	-0.009
450	+0.30	+0.91	+0.315	+0.903	+0.015	-0.007
451	+0.30	+0.91	+0.315	+0.904	+0.015	-0.006
452	+0.30	+0.91	+0.315	+0.906	+0.015	-0.004
453	+0.33	+0.91	+0.311	+0.892	-0.019	-0.018
454	+0.33	+0.91	+0.311	+0.893	-0.019	-0.017
455	+0.33	+0.91	+0.311	+0.894	-0.019	-0.016
456	+0.33	+0.91	+0.311	+0.895	-0.019	-0.015
457	+0.33	+0.91	+0.312	+0.897	-0.018	-0.013
458	+0.33	+0.91	+0.312	+0.898	-0.018	-0.012
459	+0.33	+0.94	+0.312	+0.899	-0.018	-0.041
460	+0.33	+0.94	+0.312	+0.900	-0.018	-0.040
461	+0.33	+0.94	+0.313	+0.902	-0.017	-0.038
462	+0.33	+0.94	+0.313	+0.903	-0.017	-0.037
463	+0.33	+0.94	+0.313	+0.904	-0.017	-0.036
464	+0.33	+0.94	+0.313	+0.905	-0.017	-0.035
465	+0.33	+0.94	+0.313	+0.907	-0.017	-0.033
466	+0.33	+0.94	+0.314	+0.908	-0.016	-0.032

Table G-1 TOPEX Side B Sigma0 Cal

	Cal Table Values Used in Already-Distributed GDRs		New Cal Table Values from Sigma0 Trend Fit		Delta Cal Table Values, to be Added to Already-Distributed GDR Sigma0	
467	+0.33	+0.94	+0.314	+0.909	-0.016	-0.031
468	+0.33	+0.94	+0.314	+0.910	-0.016	-0.030
469	+0.33	+0.94	+0.314	+0.912	-0.016	-0.028
470	+0.33	+0.94	+0.315	+0.913	-0.015	-0.027
471	+0.33	+0.94	+0.315	+0.914	-0.015	-0.026
472	+0.33	+0.94	+0.315	+0.915	-0.015	-0.025
473	+0.33	+0.94	+0.315	+0.917	-0.015	-0.023
474	+0.33	+0.94	+0.315	+0.918	-0.015	-0.022
475	+0.33	+0.94	+0.316	+0.919	-0.014	-0.021
476	+0.33	+0.94	+0.316	+0.920	-0.014	-0.020
477	+0.33	+0.94	+0.316	+0.922	-0.014	-0.018
478	+0.33	+0.94	+0.316	+0.923	-0.014	-0.017
479	+0.33	+0.94	+0.317	+0.924	-0.013	-0.016
480	+0.33	+0.94	+0.317	+0.925	-0.013	-0.015
481	+0.33	+0.94	+0.317	+0.927	-0.013	-0.013

Appendix H
TOPEX Range Bias Changes

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
1	15	+2.795	+1.691
2	18	+1.867	+0.644
3	18	+2.527	+1.191
4	18	+1.811	+0.929
5	20	+1.947	+0.808
6	20	+1.792	+0.975
7	14	+1.602	+0.178
8	18	+1.799	+0.194
9	17	+1.751	+0.661
10	20	+1.594	+0.253
11	20	+1.342	+0.500
12	19	+1.645	+0.757
13	15	+1.622	+0.236
14	17	+1.941	+0.532
15	19	+1.985	+0.474
16	20	+2.060	+0.461
17	21	+1.723	+0.319
18	18	+1.484	+0.223
19	16	+1.615	+0.151
21	20	+2.047	+0.149
22	20	+1.672	+0.205
23	19	+1.354	+0.355

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
24	21	+0.624	+0.289
25	20	+0.553	+0.545
26	19	+1.517	+0.155
27	20	+1.517	+0.131
28	20	+1.131	+0.217
29	20	+0.614	+0.255
30	18	+0.924	+0.372
32	18	+1.727	+0.397
33	17	+0.805	+0.869
34	20	+0.023	+0.152
35	18	-0.490	+0.606
36	20	-0.777	+0.667
37	18	+0.283	+0.482
38	19	+0.734	+0.322
39	20	+0.834	+0.406
40	21	+0.690	+0.419
42	20	-0.609	+0.536
43	19	-0.081	+0.240
44	17	+0.152	+0.227
45	20	+0.170	+0.223
46	19	-0.316	+0.655
47	19	-1.348	+0.334
48	19	-0.148	+0.588
49	18	-0.165	+0.421
50	19	+1.349	+0.603

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
51	20	-0.076	+0.723
52	20	-0.183	+0.270
53	20	-1.823	+0.666
54	21	-0.810	+0.702
56	20	-0.435	+0.715
57	20	-1.059	+0.418
58	20	-0.957	+0.323
59	20	-2.053	+0.580
60	20	-2.299	+0.543
61	19	-1.569	+0.236
62	20	-1.455	+0.157
63	20	-1.392	+0.158
64	21	-2.245	+0.554
66	20	-1.488	+0.154
67	19	-1.843	+0.400
68	20	-0.302	+0.639
69	20	-2.039	+0.472
70	20	-2.554	+1.102
71	20	-3.780	+0.575
72	20	-4.598	+1.804
73	19	-2.411	+0.518
74	20	-2.742	+0.410
75	20	-3.112	+0.595
76	19	-2.598	+0.483
77	19	-3.883	+0.374

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
78	20	-3.715	+0.444
80	19	-3.059	+0.350
81	20	-3.526	+0.300
82	20	-5.491	+1.251
83	20	-4.814	+0.724
84	20	-3.976	+0.258
85	20	-3.276	+1.038
86	20	-1.596	+1.172
87	20	-4.199	+0.212
88	21	-4.296	+0.252
89	20	-4.434	+0.327
90	20	-4.181	+0.262
92	19	-3.524	+0.172
93	20	-3.732	+0.244
94	20	-3.918	+0.273
95	20	-4.374	+0.294
96	19	-4.268	+0.248
98	19	-3.373	+0.152
99	20	-3.528	+0.161
100	19	-3.759	+1.072
101	20	-4.003	+0.232
102	20	-3.895	+0.161
104	20	-2.646	+1.185
105	20	-3.457	+0.213
106	20	-3.779	+0.499

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
107	20	-4.509	+0.207
108	19	-3.955	+0.196
109	19	-3.808	+0.168
110	20	-3.705	+0.252
111	20	-3.727	+0.143
112	20	-4.028	+0.351
113	20	-4.251	+0.202
115	17	-3.092	+0.336
116	20	-3.045	+0.295
117	16	-3.191	+0.299
118	2	-1.832	+3.533
119	17	-5.211	+1.013
120	20	-4.668	+0.454
121	19	-3.735	+0.675
122	20	-4.013	+0.622
123	13	-4.242	+0.658
124	20	-4.758	+0.797
125	21	-4.860	+0.574
127	19	-3.726	+0.617
128	20	-3.983	+0.310
129	20	-3.722	+0.214
130	20	-4.125	+0.783
131	20	-2.970	+0.615
132	19	-2.120	+0.172
133	20	-1.948	+0.127

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
134	20	-1.764	+0.184
135	20	-2.604	+0.710
136	20	-2.878	+0.371
137	21	-1.968	+0.904
139	20	+0.712	+0.893
140	20	-1.252	+0.839
141	20	-1.464	+0.285
142	20	-2.613	+0.539
143	19	-2.626	+0.558
144	18	-1.490	+0.210
145	21	-1.980	+0.377
146	20	-1.569	+0.408
147	19	-1.736	+0.341
148	18	-3.065	+0.336
149	20	-2.741	+0.630
151	20	-1.701	+1.027
152	20	-1.737	+0.208
153	20	-2.548	+0.751
154	20	-2.961	+0.288
155	20	-2.214	+0.683
156	19	-1.607	+0.511
157	20	+0.794	+0.815
158	20	-1.144	+0.562
159	20	-1.162	+0.776
160	20	-2.779	+0.385

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
161	21	-2.641	+0.886
163	19	-1.277	+0.296
164	20	-0.881	+0.186
165	20	-2.058	+1.000
166	20	-2.405	+0.241
167	20	-1.566	+0.707
168	19	-0.960	+0.235
169	20	-1.283	+0.219
170	20	-0.935	+0.159
171	21	-1.454	+0.400
172	20	-1.447	+0.453
173	20	-0.380	+0.227
175	16	+1.732	+0.436
176	20	+0.317	+0.346
177	21	+0.428	+0.383
178	20	-0.382	+0.186
179	20	+0.148	+0.671
181	19	+1.211	+0.886
182	20	+1.084	+0.150
183	20	+0.556	+0.510
184	19	+0.142	+0.253
185	20	+0.616	+0.170
187	20	+0.845	+0.719
188	20	+0.638	+0.242
189	20	+0.183	+0.410

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
190	20	+0.302	+0.348
191	20	+0.898	+0.213
192	20	+1.983	+1.237
193	20	+3.390	+1.249
194	17	+1.498	+0.814
195	19	+1.046	+0.888
196	18	+0.543	+0.504
198	19	+2.804	+0.583
199	19	+2.757	+0.229
200	20	+2.735	+0.224
201	20	+1.946	+0.222
202	19	+2.042	+0.302
203	18	+2.720	+0.419
204	17	+2.915	+0.220
205	20	+3.023	+0.269
206	19	+3.051	+0.640
207	19	+3.062	+0.652
208	20	+3.043	+0.689
210	17	+5.088	+0.196
211	15	+4.662	+0.297
212	20	+4.712	+0.365
213	20	+3.015	+0.603
214	20	+3.668	+0.389
215	21	+3.534	+0.862
217	20	+4.867	+0.356

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
218	20	+3.684	+0.759
219	19	+4.089	+0.307
220	19	+3.935	+0.655
221	19	+5.502	+0.294
222	20	+5.536	+0.254
223	20	+5.537	+0.291
225	20	+4.867	+0.407
226	19	+4.488	+0.733
227	21	+5.880	+0.332
228	21	+6.780	+0.662
229	20	+6.738	+0.591
230	20	+6.430	+0.594
231	20	+5.453	+0.591
232	20	+5.259	+0.647
233	19	+6.365	+0.897
235	18	+7.086	+0.266
236	21	-0.373	+0.351
237	21	+0.336	+0.490
238	20	+0.599	+0.755
239	19	+1.163	+0.333
240	20	+1.019	+0.284
241	20	+1.191	+0.284
242	21	+0.480	+0.609
244	20	+1.062	+0.673
245	19	+1.388	+0.386

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
246	20	+1.448	+0.288
247	20	+1.554	+0.445
248	20	+1.793	+0.398
249	20	+1.018	+0.368
250	20	+0.657	+0.383
251	19	+1.637	+0.408
252	19	+2.460	+0.256
253	20	+2.088	+0.472
254	22	+1.749	+0.328
255	21	+1.749	+0.530
257	18	+1.649	+0.346
258	20	+1.956	+0.304
259	20	+1.473	+0.400
260	20	+1.339	+0.431
261	20	+1.269	+0.292
262	20	+1.201	+0.264
263	19	+1.135	+0.338
264	21	+1.950	+0.599
265	20	+0.929	+0.356
267	20	+1.383	+0.327
268	20	+1.335	+0.494
269	19	+1.541	+0.317
270	20	+1.654	+0.234
271	20	+1.716	+0.297
272	21	+1.334	+0.288

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
273	20	+1.605	+0.409
274	20	+1.690	+0.226
275	18	+1.530	+0.248
276	19	+1.509	+0.316
277	21	+1.651	+0.317
279	20	+1.927	+0.257
280	19	+1.513	+0.283
281	19	+1.609	+0.339
282	20	+1.665	+0.273
283	19	+1.630	+0.223
284	19	+1.596	+0.351
285	20	+1.375	+0.299
286	20	+1.868	+0.301
287	18	+1.851	+0.273
288	20	+1.951	+0.325
290	20	+1.697	+0.265
291	20	+1.953	+0.332
292	20	+1.903	+0.312
293	18	+1.856	+0.275
294	20	+1.589	+0.318
295	19	+1.882	+0.210
296	19	+1.654	+0.258
297	20	+1.817	+0.255
298	18	+1.878	+0.271
300	20	+2.442	+0.399

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
301	23	+2.147	+0.309
302	18	+2.149	+0.428
303	19	+1.910	+0.384
304	19	+1.882	+0.423
305	19	+1.384	+0.242
306	20	+1.301	+0.216
308	20	+1.623	+0.333
309	20	+1.924	+0.307
310	19	+1.578	+0.316
311	20	+1.830	+0.365
312	20	+1.544	+0.257
313	19	+1.678	+0.267
314	20	+1.224	+0.208
315	21	+1.691	+0.310
316	19	+1.478	+0.301
317	20	+2.027	+0.459
318	20	+1.358	+0.315
319	20	+1.932	+0.377
320	20	+1.393	+0.292
321	19	+1.548	+0.311
322	19	+1.803	+0.483
323	19	+1.773	+0.328
324	20	+1.697	+0.362
325	20	+1.530	+0.340
326	20	+1.651	+0.348

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
327	19	+2.132	+0.275
328	19	+1.657	+0.428
329	20	+1.918	+0.238
330	18	+1.633	+0.379
331	20	+2.013	+0.349
332	20	+1.488	+0.256
333	20	+1.874	+0.392
334	19	+1.692	+0.372
335	20	+2.031	+0.283
336	20	+1.662	+0.406
337	20	+2.076	+0.383
338	20	+2.330	+0.318
339	20	+2.714	+0.312
340	19	+2.484	+0.342
341	20	+2.482	+0.355
342	20	+2.844	+0.356
343	19	+2.269	+0.301
344	20	+2.462	+0.345
345	20	+2.280	+0.344
346	19	+2.750	+0.389
347	20	+2.809	+0.328
348	20	+2.598	+0.283
349	20	+2.136	+0.455
350	20	+2.073	+0.347
351	20	+2.419	+0.289

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
352	19	+2.433	+0.255
353	20	+2.564	+0.254
354	19	+2.393	+0.296
355	19	+2.741	+0.304
356	19	+2.353	+0.201
357	19	+2.730	+0.300
358	19	+3.231	+0.190
359	20	+3.248	+0.178
360	20	+3.018	+0.329
362	19	+2.773	+0.343
363	20	+2.720	+0.386
364	19	-0.756	+1.672
365	19	+0.522	+2.218
366	20	+2.254	+0.927
367	20	+1.893	+0.963
368	20	+1.788	+1.285
369	16	-0.274	+1.826
370	13	+0.901	+2.143
371	12	-1.550	+1.389
372	14	-0.620	+1.844
373	15	+0.908	+1.741
374	12	+1.614	+1.014
375	16	+1.366	+2.321
376	12	-2.247	+0.238
377	14	-2.125	+0.256

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
378	19	+1.072	+1.682
379	19	-0.406	+0.996
380	20	+1.351	+2.361
381	16	-1.499	+0.601
382	17	+0.666	+1.180
383	18	-1.857	+0.933
384	19	+1.401	+1.888
385	17	-1.756	+1.078
386	16	-0.069	+2.021
387	14	-0.155	+1.546
388	12	-0.448	+1.133
389	19	-0.541	+0.556
390	18	+1.056	+1.279
391	19	-1.199	+1.186
392	20	-2.345	+0.712
393	18	+0.744	+1.283
394	14	+1.408	+0.250
395	13	+0.437	+1.578
396	18	-1.266	+0.858
397	18	-1.055	+0.428
398	17	+2.387	+1.952
399	14	+0.368	+1.712
400	15	+3.538	+0.223
401	16	+0.446	+1.626
402	15	+1.353	+2.447

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
403	20	-0.182	+1.167
404	20	-0.468	+2.294
405	18	+2.014	+2.258
406	14	+1.652	+1.304
407	18	+1.124	+2.246
408	20	+1.658	+2.428
409	16	-0.386	+1.080
410	17	-0.907	+0.542
411	14	+2.032	+1.234
412	14	+3.631	+0.426
413	17	+2.667	+2.087
414	16	-0.934	+0.276
415	19	-0.419	+1.317
416	18	+2.738	+1.851
417	15	+2.197	2.320
418	12	+1.016	1.667
419	19	+1.634	2.368
420	18	-0.783	1.362
421	16	+3.450	0.406
422	17	+0.968	1.738
423	12	+0.193	1.948
424	18	-0.188	1.710
425	18	+0.143	1.620
426	15	+0.191	2.311
427	20	-2.093	0.298

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
428	18	+0.368	1.836
429	17	-1.834	0.222
430	14	-1.695	0.229
433	15	-0.503	1.496
434	16	+3.037	1.785
435	12	+2.756	1.266
436	17	+2.306	2.742
437	16	+4.237	0.360
438	16	+2.050	1.193
439	19	+1.282	1.232
440	18	+3.658	1.226
441	12	+2.820	2.064
442	10	+1.469	0.934
443	14	+4.809	0.286
444	15	+3.023	2.273
445	16	+2.492	1.566
446	15	+4.634	1.013
447	4	+4.911	0.131
448	6	+4.117	0.443
449	13	+2.985	1.509
450	13	+2.184	1.921
451	13	+4.562	1.413
452	12	+4.150	1.490
453	11	+5.365	0.293
454	18	+4.915	1.352

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
455	17	+4.700	2.097
456	20	+3.582	1.950
457	17	+4.712	1.501
458	19	+5.786	1.043
459	11	+5.554	0.348
460	15	+5.797	0.366
461	17	+5.987	0.282
462	19	+5.174	0.372
463	14	+4.543	1.090
464	17	+5.733	0.912
465	15	+6.077	0.222
466	14	+6.141	0.276
467	18	+4.755	0.973
468	18	+5.498	0.368
469	17	+5.667	0.703
470	13	+5.993	0.341
471	12	+5.616	0.412
472	16	+6.175	0.254
473	19	+6.122	0.216
474	19	+5.425	0.692
475	19	+5.017	1.147
476	16	+5.774	0.261
477	17	+5.588	0.322
478	17	+5.989	0.249
479	19	+5.870	0.395

Table H-1 TOPEX Range Bias Changes Based on CAL1 Step 5 (No Temperature Correction) (Continued)

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
480	19	+5.809	0.275
481	9	+5.321	0.267

Appendix I

JASON/TOPEX Range Measurement Noise Level (NL) Comparison Until the TOPEX End-of-Mission

Table I-1 JASON/TOPEX Range Measurement Noise Level (NL) Comparison until the TOPEX End-of-Mission

JASON CYCLE	JASON # PTS	JASON MEAN NL (cm)	JASON NL at 2m (cm)	DELTA MEAN NL JAS-TPX (cm)	DELTA NL at 2 JAS-TPX (cm)	TOPEX NL at 2m (cm)	TOPEX MEAN NL (cm)	TOPEX # PTS	TOPEX CYCLE
2				0.000	0.000	1.777	2.802	3213	345
3	5217	3.145	2.797	0.288	1.008	1.789	2.857	3364	346
4	5186	3.114	2.804	0.365	0.993	1.811	2.749	3314	347
5	5174	3.028	2.798	0.380	0.995	1.803	2.648	3036	348
6	4944	3.100	2.768	0.350	0.983	1.785	2.750	3232	349
7	5237	3.216	2.828	0.301	1.038	1.790	2.915	3044	350
8	137	3.558	2.954	0.607	1.171	1.783	2.951	3064	351
9	5139	3.222	2.842	0.349	1.051	1.791	2.873	3114	352
10	5296	3.203	2.827	0.278	1.036	1.791	2.925	3105	353
11	5106	3.157	2.779	0.236	0.998	1.781	2.921	3107	354
12	3456	3.208	2.813	0.318	1.022	1.791	2.890	3195	355
13	3000	3.149	2.807	0.295	1.019	1.788	2.854	2976	356
14	5271	3.207	2.814	0.176	1.003	1.811	3.031	3081	357
15	4919	3.204	2.812	0.329	1.024	1.788	2.875	3192	358
16	5156	3.215	2.804	0.242	1.041	1.763	2.973	3253	359
17	5287	3.269	2.791	0.000	0.000				361
18	5230	3.219	2.802	0.146	1.021	1.781	3.073	3172	360
19	5031	3.214	2.813	0.231	1.021	1.792	2.983	2886	362
20	5411	3.303	2.827	0.082	1.026	1.801	3.221	3073	363
21	5420	3.249	2.794	0.151	1.017	1.777	3.098	3171	364
22	4956	3.305	2.854	0.232	1.090	1.764	3.073	2550	365
23	4863	3.124	2.824	0.224	1.063	1.761	2.900	2368	366
24	4903	3.150	2.799	0.230	1.006	1.793	2.920	3226	367

Table I-1 JASON/TOPEX Range Measurement Noise Level (NL) Comparison until the TOPEX End-of-Mission (Continued)

JASON CYCLE	JASON # PTS	JASON MEAN NL (cm)	JASON NL at 2m (cm)	DELTA MEAN NL JAS-TPX (cm)	DELTA NL at 2 JAS-TPX (cm)	TOPEX NL at 2m (cm)	TOPEX MEAN NL (cm)	TOPEX # PTS	TOPEX CYCLE
25	4905	3.146	2.802	0.267	1.016	1.786	2.879	2950	368
26	4909	3.074	2.815	0.183	1.028	1.787	2.891	2519	369
27	4821	3.113	2.809	0.283	1.013	1.796	2.830	2881	370
28	4874	3.148	2.810	0.204	1.020	1.790	2.944	2338	371
29	4779	3.086	2.825	0.268	1.016	1.809	2.818	2218	372
30	4763	3.045	2.767	0.377	0.956	1.811	2.668	2777	373
31	4878	3.100	2.735	0.231	0.950	1.785	2.869	3247	374
32	4200	3.049	2.737	0.309	0.970	1.767	2.740	2858	375
33	4758	3.132	2.737	0.164	0.968	1.769	2.968	2961	376
34	4833	3.131	2.782	0.329	1.011	1.771	2.802	2830	377
35	4802	3.015	2.755	0.313	0.962	1.793	2.702	2961	378
36	4763	3.072	2.755	0.179	0.986	1.769	2.893	2778	379
37	4833	3.089	2.777	0.225	0.977	1.800	2.864	2911	380
38	5003	3.130	2.781	0.239	1.011	1.770	2.891	3073	381
39	4995	3.070	2.792	0.322	0.997	1.795	2.748	3249	382
40	5154	3.085	2.782	0.275	0.987	1.795	2.810	3039	383
41	4886	3.122	2.747	0.168	0.936	1.811	2.954	2921	384
42	5008	3.101	2.782	0.362	0.994	1.788	2.739	2944	385
43	5132	3.112	2.780	0.205	0.993	1.787	2.907	2921	386
44	5162	3.169	2.846	0.260	1.075	1.771	2.909	2794	387
45	5047	3.140	2.799	0.304	0.995	1.804	2.836	2901	388
46	4729	2.977	2.503	-0.032	0.711	1.792	3.009	2947	389
47	4916	2.939	2.528	-0.072	0.737	1.791	3.011	2851	390
48	4979	2.882	2.510	0.054	0.708	1.802	2.828	2908	391
49	5169	2.925	2.514	0.135	0.717	1.797	2.790	3108	392
50	5061	3.022	2.525	-0.037	0.755	1.770	3.059	2890	393
51	5012	2.971	2.548	0.127	0.727	1.821	2.844	2841	394
52	4888	2.958	2.534	0.065	0.718	1.816	2.893	2693	395

Table I-1 JASON/TOPEX Range Measurement Noise Level (NL) Comparison until the TOPEX End-of-Mission (Continued)

JASON CYCLE	JASON # PTS	JASON MEAN NL (cm)	JASON NL at 2m (cm)	DELTA MEAN NL JAS-TPX (cm)	DELTA NL at 2 JAS-TPX (cm)	TOPEX NL at 2m (cm)	TOPEX MEAN NL (cm)	TOPEX # PTS	TOPEX CYCLE
53	5044	2.969	2.537	0.009	0.739	1.798	2.960	2860	396
54	4874	2.904	2.534	0.076	0.739	1.795	2.828	2784	397
55	4991	2.975	2.523	0.126	0.739	1.784	2.849	2857	398
56	5061	3.073	2.556	0.037	0.768	1.788	3.036	3109	399
57	4981	3.048	2.527	-0.018	0.752	1.775	3.066	3005	400
58	4927	2.976	2.556	0.139	0.757	1.799	2.837	2701	401
59	4928	2.937	2.561	0.263	0.763	1.798	2.674	2644	402
60	4935	2.907	2.539	0.181	0.748	1.791	2.726	2588	403
61	4972	2.906	2.556	0.294	0.765	1.791	2.612	2737	404
62	4970	2.960	2.558	0.068	0.757	1.801	2.892	2863	405
63	4918	2.894	2.538	0.150	0.721	1.817	2.744	2709	406
64	4743	2.814	2.534	0.076	0.719	1.815	2.738	2682	407
65	4792	2.833	2.508	0.014	0.721	1.787	2.819	2706	408
66	4789	2.800	2.498	0.083	0.688	1.810	2.717	2580	409
67	4964	2.821	2.493	0.060	0.714	1.779	2.761	2924	410
68	4420	2.856	2.495	0.048	0.696	1.799	2.808	3075	411
69	249	2.805	2.475	0.076	0.683	1.792	2.729	2367	412
70	4834	2.863	2.504	-0.025	0.716	1.788	2.888	2156	413
71	4743	2.829	2.491	0.020	0.712	1.779	2.809	3027	414
72	4802	2.845	2.499	0.046	0.710	1.789	2.799	2675	415
73	4969	2.747	2.492	0.149	0.726	1.766	2.598	2797	416
74	4812	2.895	2.507	0.073	0.703	1.804	2.822	2817	417
75	4802	2.804	2.525	0.181	0.701	1.824	2.623	2787	418
76	4944	2.788	2.491	0.168	0.699	1.792	2.620	2698	419
77	3593	2.849	2.491	0.151	0.706	1.785	2.698	2747	420
78	3149	2.840	2.515	-0.057	0.709	1.806	2.897	2843	421
79	5032	2.865	2.502	-0.034	0.701	1.801	2.899	3032	422
80	4847	2.878	2.477	0.034	0.688	1.789	2.844	2935	423

Table I-1 JASON/TOPEX Range Measurement Noise Level (NL) Comparison until the TOPEX End-of-Mission (Continued)

JASON CYCLE	JASON # PTS	JASON MEAN NL (cm)	JASON NL at 2m (cm)	DELTA MEAN NL JAS-TPX (cm)	DELTA NL at 2 JAS-TPX (cm)	TOPEX NL at 2m (cm)	TOPEX MEAN NL (cm)	TOPEX # PTS	TOPEX CYCLE
81	4856	2.935	2.518	0.066	0.714	1.804	2.869	2797	424
82	3674	2.927	2.496	-0.022	0.721	1.775	2.949	2639	425
83	4893	2.935	2.505	0.005	0.711	1.794	2.930	2741	426
84	4883	3.003	2.515	0.009	0.718	1.797	2.994	2870	427
85	5168	2.961	2.498	0.016	0.714	1.784	2.945	3125	428
86	5119	2.867	2.514	0.384	0.703	1.811	2.483	2512	429
87	4930	2.938	2.554	0.189	0.735	1.819	2.749	2043	430
88	5049	3.048	2.544	0.000	0.000				431
89	5023	2.917	2.525	0.000	0.000				432
90	5020	2.999	2.515	-0.016	0.715	1.800	3.015	1906	433
91	4481	2.997	2.516	0.288	0.745	1.771	2.709	884	434
92	4965	2.930	2.550	0.192	0.774	1.776	2.738	1346	435
93	4947	2.973	2.569	0.037	0.787	1.782	2.936	1422	436
94	4992	2.913	2.554	0.250	0.768	1.786	2.663	1894	437
95	5002	2.970	2.539	0.118	0.746	1.793	2.852	2600	438
96	4983	2.926	2.525	0.104	0.729	1.796	2.822	2800	439
97	5005	2.902	2.544	0.173	0.736	1.808	2.729	2719	440
98	4886	2.975	2.548	0.076	0.751	1.797	2.899	2210	441
99	4862	2.937	2.516	0.064	0.709	1.807	2.873	2524	442
100	4908	2.827	2.520	0.163	0.743	1.777	2.664	2062	443
101	4806	2.872	2.504	0.096	0.686	1.818	2.776	2579	444
102	4799	2.811	2.484	0.094	0.707	1.777	2.717	2205	445
103	4956	2.856	2.504	0.073	0.719	1.785	2.783	2017	446
104	4732	2.758	2.475	0.119	0.675	1.800	2.639	2059	447
105	4599	2.795	2.481	0.063	0.698	1.783	2.732	1882	448
106	4840	2.752	2.472	0.061	0.692	1.780	2.691	2229	449
107	4705	2.819	2.466	0.101	0.690	1.776	2.718	1667	450
108	4580	2.813	2.443	-0.099	0.649	1.794	2.912	1205	451

Table I-1 JASON/TOPEX Range Measurement Noise Level (NL) Comparison until the TOPEX End-of-Mission (Continued)

JASON CYCLE	JASON # PTS	JASON MEAN NL (cm)	JASON NL at 2m (cm)	DELTA MEAN NL JAS-TPX (cm)	DELTA NL at 2 JAS-TPX (cm)	TOPEX NL at 2m (cm)	TOPEX MEAN NL (cm)	TOPEX # PTS	TOPEX CYCLE
109	4854	2.767	2.476	0.081	0.681	1.795	2.686	2450	452
110	4979	2.831	2.449	0.169	0.664	1.785	2.662	2530	453
111	4898	2.808	2.426	-0.041	0.638	1.788	2.849	2497	454
112	4810	2.752	2.453	0.044	0.660	1.793	2.708	2331	455
113	2385	2.781	2.446	-0.080	0.655	1.791	2.861	2701	456
114	4830	2.806	2.497	0.086	0.699	1.798	2.720	2521	457
115	4817	2.786	2.492	0.081	0.686	1.806	2.705	2446	458
116	4881	2.959	2.493	-0.040	0.716	1.777	2.999	2105	459
117	4717	2.914	2.528	0.023	0.748	1.780	2.891	2142	460
118	4770	2.828	2.527	0.104	0.730	1.797	2.724	2102	461
119	5040	2.905	2.497	0.045	0.705	1.792	2.860	2599	462
120	4599	2.955	2.453	-0.008	0.671	1.782	2.963	2701	463
121	4690	2.884	2.463	0.096	0.670	1.793	2.788	2036	464
122	4546	2.884	2.498	0.032	0.713	1.785	2.852	1511	465
123	4618	2.883	2.465	0.157	0.681	1.784	2.726	2404	466
124	4606	2.887	2.483	0.092	0.684	1.799	2.795	2383	467
125	4847	2.928	2.507	0.111	0.707	1.800	2.817	2251	468
126	4825	2.896	2.497	0.121	0.698	1.799	2.775	2334	469
127	5044	2.893	2.522	0.223	0.724	1.798	2.670	2362	470
128	5118	2.954	2.522	0.164	0.715	1.807	2.790	2202	471
129	4999	3.051	2.513	0.136	0.705	1.808	2.915	2172	472
130	4998	2.963	2.481	0.185	0.680	1.801	2.778	2194	473
131	4748	2.897	2.545	0.294	0.751	1.794	2.603	1756	474
132	4748	2.960	2.510	0.283	0.718	1.792	2.677	1999	475
133	4065	2.874	2.486	0.177	0.680	1.806	2.697	2153	476
134	4141	2.866	2.511	0.018	0.709	1.802	2.848	2449	477
135	3150	2.816	2.456	-0.050	0.649	1.807	2.866	2326	478
136	1491	2.825	2.445	0.066	0.644	1.801	2.759	1467	479

Table I-1 JASON/TOPEX Range Measurement Noise Level (NL) Comparison until the TOPEX End-of-Mission (Continued)

JASON CYCLE	JASON # PTS	JASON MEAN NL (cm)	JASON NL at 2m (cm)	DELTA MEAN NL JAS-TPX (cm)	DELTA NL at 2 JAS-TPX (cm)	TOPEX NL at 2m (cm)	TOPEX MEAN NL (cm)	TOPEX # PTS	TOPEX CYCLE
137	2771	2.866	2.475	0.056	0.711	1.764	2.810	1804	480
138	4796	2.847	2.476	0.027	0.672	1.804	2.820	783	481

Appendix J

Topography Experiment (TOPEX) Software Documentation Series

TOPEX Radar Altimeter Development Requirements and Specifications, NASA/TM-2003-212236, Volume 1, May 2003.

WFF TOPEX Software Documentation Overview, NASA/TM-2003-212236, Volume 2, May 2003.

WFF TOPEX Software Documentation Altimeter Instrument File (AIF) Processing, NASA/TM-2003-212236, Volume 3, July 2003.

TOPEX Sensor Data Record (SDR) Processing, NASA/TM-2003-212236, Volume 4, July 2003.

TOPEX Geophysical Data Record (GDR) Processing, NASA/TM-2003-212236, Volume 5, Rev. 1, July 2003.

TOPEX NASA Altimeter Operations Handbook, NASA/TM-2003-212236, Volume 6, September 2003.

TOPEX Mission Radar Altimeter Engineering Assessment Report, NASA/TM-2003-212236, Volume 7, September 2003.

TOPEX Mission Radar Altimeter Engineering Assessment Report, Update: Launch to January 1, 1995, NASA/TM-2003-212236, Volume 8, November 2003.

TOPEX Radar Altimeter Engineering Assessment Report, Update: Launch to January 1, 1996, NASA/TM-2003-212236, Volume 9, November 2003.

TOPEX Radar Altimeter Engineering Assessment Report, Update: Launch to January 1, 1997, NASA/TM-2003-212236, Volume 10, November 2003.

TOPEX Radar Altimeter Engineering Assessment Report, Update: Launch to January 1, 1998, NASA/TM-2003-212236, Volume 11, November 2003.

TOPEX Radar Altimeter Engineering Assessment Report, Update: From Launch to Turn-Off of Side A on February 10, 1999, NASA/TM-2003-212236, Volume 12, November 2003.

TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2000, NASA/TM-2003-212236, Volume 13, November 2003.

TOPEX Special Processing, NASA/TM-2003-212236, Volume 14, Rev. 2, December 2003.

TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2001, NASA/TM-2003-212236, Volume 15, December 2003.

TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2002, NASA/TM-2003-212236, Volume 16, December 2003.

TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2003, NASA/TM-2004-212236, Volume 17, February 2004.

TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2004, NASA/TM-2004-212236, Volume 18, April 2004.

TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2005, NASA/TM-2005-212236, Volume 19, November 2005.

JASON Geophysical Data Record (GDR) Processing, NASA/TM-2005-212236, Volume 20, December 2005.

TOPEX Radar Altimeter Engineering Assessment Report, Final Update: From Side B Turn-On to End-of-Mission on October 9, 2005, NASA/TM-2006-212236, Volume 21, May 2006.

Abbreviations & Acronyms

ACQ	Acquire
AGC	Automatic Gain Control
AIF	Altimeter Instrument File
ALT	Altimeter
ATA	Adaptive Tracker Assembly
ATU	Adaptive Tracker Unit
AVISO	Archivage, Validation et Interprétation des données des Satellites Océanographiques is the French multi-satellite databank dedicated to space oceanography, developed by CNES.
C	C-Band
CAL	Calibration Mode or Calibration Mode data
CAL/VAL	Calibration/Validation
CGEN	Chirp Generator
CM	Centimeters
CNES	Centre National d'Etudes Spatiales, the French Space Agency
CSSA	C-band Solid State Amplifier
dB	decibels
DCG	Digital C Gate
DFB	Digital Filter Bank
EML	Early/Middle/Late (Gate-Tracking)
ENG	Engineering Data
FTP	File Transfer Protocol
GDR	Geophysical Data Record
GSFC	Goddard Space Flight Center
ICA	Interface Control Assembly
ICU	S/C Interface Control Unit
IF	Intermediate Frequency
IGDR	Interim Geophysical Data Record
JASON-1	Follow-on mission to TOPEX

JPL	Jet Propulsion Laboratory
Ku	Ku-Band
LVPS	Low Voltage Power Supply
MCR	MOS Change Request
M	Meters
MM	Millimeters
MOS	Mission Operations System
MTU	Microwave Transmission Unit
NASA	National Aeronautics and Space Administration
NRA	NASA Radar Altimeter
PODAAC	Physical Oceanography Distributed Active Archive Center is one element of the Earth Observing System Data and Information System (EOSDIS), developed by NASA.
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval, period is 980 us.
PSU	Power Switching Unit
PTR	Point Target Response
RIU	Remote Interface Unit
RCS	Radar Cross Section
RCVR	Receiver
RF	Radio Frequency Subsystem
RMS	Root Mean Square
SACU	Synchronizer/Acquisition/Calibrate Unit
S/C	Spacecraft
SCI	Science
SEU	Single Event Upset
SSALT	Solid-State Radar Altimeter
SSH	Sea Surface Height
SSU	Signal Switch Unit
SW	Software
SWH	Significant Wave Height

TR	Tape Recorder
TM	Telemetry
TOPEX/POSEIDON	Ocean Topography Experiment
TOTM	TOPEX Orbit Transfer Maneuver
TRK	Track
TWTA	Traveling Wave Tube Amplifier
UCFM	Up-Converter/Frequency Multiplier
UTC	Universal Time Code
WFF	Wallops Flight Facility

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14. ABSTRACT
This is the thirteenth and final report in a series of TOPEX Radar Altimeter Engineering Assessment Reports. The initial TOPEX Radar Altimeter Engineering Assessment Report, in February 1994, presented performance results for the NASA Radar Altimeter on the TOPEX/POSEIDON spacecraft, from its launch in August 1992 to February 1994. Since the time of that initial report and prior to this report, there have been eleven interim supplemental Engineering Assessment Reports, issued in March 1995, May 1996, March 1997, June 1998, August 1999, September 2000, June 2001, March 2002, May 2003, April 2004 and September 2005. The sixth supplement in September 2000 was the first assessment report that addressed Side B performance, and presented the altimeter performance from Side B turn-on until the end of calendar year 1999. This report extends the performance assessment of Side B to the final collection of data on October 9, 2005, and includes the performance assessment of Jason-1, the TOPEX follow-on mission, launched on December 7, 2001. This report provides some comparisons of Side A and Side B performance.

15. SUBJECT TERMS
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