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Volume 18

TOPEX Radar Altimeter Engineering Assessment Report Update Side B Turn-On to January 1, 2004

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April 2004

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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 Center Wallops Flight Facility over a period starting before the TOPEX launch in 1992 and continuing over greater than the 10 year TOPEX lifetime. 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 in a series of internal reports over the life of the mission. The original reports are being printed in this series without change in order to make the information more publicly available as the original investigators become less available to explain the altimeter operation and details of the various data anomalies that have been resolved.

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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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Dennis W. Lockwood/Raytheon ITSS
Annette M. Conger/Raytheon ITSS
Carol T. Purdy/Raytheon ITSS

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 eleventh 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 nine interim supplemental Engineering Assessment Reports, issued in March 1995, May 1996, March 1997, June 1998, August 1999, September 2000, June 2001, March 2002 and again in May 2003.

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 end of calendar year 2003 and includes the performance assessment of Jason-1, the TOPEX follow-on mission, launched on December 7, 2001.

Over the years since TOPEX/POSEIDON launch, we have performed a large 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 findings are presented here.

Section 2

On-Orbit Instrument Performance (Cycles 379 through 415)

From the time of the initial turn-on of Side B on February 10, 1999, to the end of 2003, the NASA Radar Altimeter has been in TRACK mode for a total of approximately 40,700 hours. The altimeter has been in IDLE mode for an additional 1880 hours, generally due to the French Altimeter's being turned on. The French Altimeter has been turned on only once since January 23, 2001; that was during cycle 361 (2002-183 to 2002-193). The altimeter has not been in IDLE mode during 2003.

The NASA altimeter has been OFF for a total of 51 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; and a 27-hour spacecraft level safehold on November 24, 2000. Since the start of 2001, the altimeter has never been in OFF mode.

Since the Jason-1 launch on December 7, 2001, TOPEX flew in tandem for approximately 240 days with measurements separated by 73 seconds, until transferred to the new interspaced orbit. TOPEX/Poseidon was transferred to a new obit during cycle 368 (2002-227 to 2002-259), 1282 days from Side B turn-on. To the end of the assessment period (January 1, 2004) covered by this report, TOPEX has been in the new interspaced orbit for a total of 470 days.

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 has two submodes designated CAL-1 and CAL-2. In CAL-1 a portion of the transmitter output is fed back to the receiver through a digitally controlled calibration attenuator and delay line. The altimeter acquires and tracks this calibration signal for 10 seconds at each of 17 different preset calibration attenuator values; each calibration attenuator value is changed by 2 dB from its neighbor. The altimeter's CAL-1 has almost the same signal path as the normal fine-track mode, except that CAL-1 has a delay line, a different attenuator, and switches to select these components. The altimeter's automatic gain control (AGC) loop is active during each CAL-1 step, so changes in CAL-1 range and AGC should be directly relatable to changes in the altimeter's fine-track range and power estimation. The AGC level of CAL-1 Step 5 best represents the average level seen in normal over-ocean fine-tracking, so CAL-1 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 enters CAL-1 and then CAL-2. Each of the 17 steps within CAL-1 lasts about 10 seconds, and then CAL-2 lasts about a minute, so the entire calibration sequence lasts about 4 minutes. Internal altimeter calibrations are scheduled twice-per-day, over land areas, at approximately 0000 UTC and 1200 UTC. Internal calibrations are also performed whenever the NASA altimeter is commanded from TRACK to IDLE for a period of tracking by the French altimeter, or from IDLE back to TRACK when tracking resumes for the NASA altimeter. The calibrations prior to and after the French altimeter operations are not constrained to land areas, and usually occur over open ocean.

Our processing of the CAL-1 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 have been 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 2003, is plotted in Figure 2-1 "Ku-Band Range CAL-1 Results" on page 2-4. CAL-1 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 2001. Since day 2002-214, the Ku-Band delta range has undergone irregular periods of oscillations that have dipped to the -4 mm level. These oscillations, cause unknown, are discussed in Section 3.

In Figure 2-1, the >20 mm decrease at day 1247 (2002-193) was 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 Table 2-2 Side B Key Events, entry Day 2002-193.

Of the four positive (~+18 mm amplitude) Ku CAL-1 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 change in C-Band calibration range is depicted in Figure 2-2 "C-Band Range CAL-1 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 2002, there has been a negative drift of approximately 5 mm.

Range calibrations and their correction values are discussed in more detail in Section 3.1.

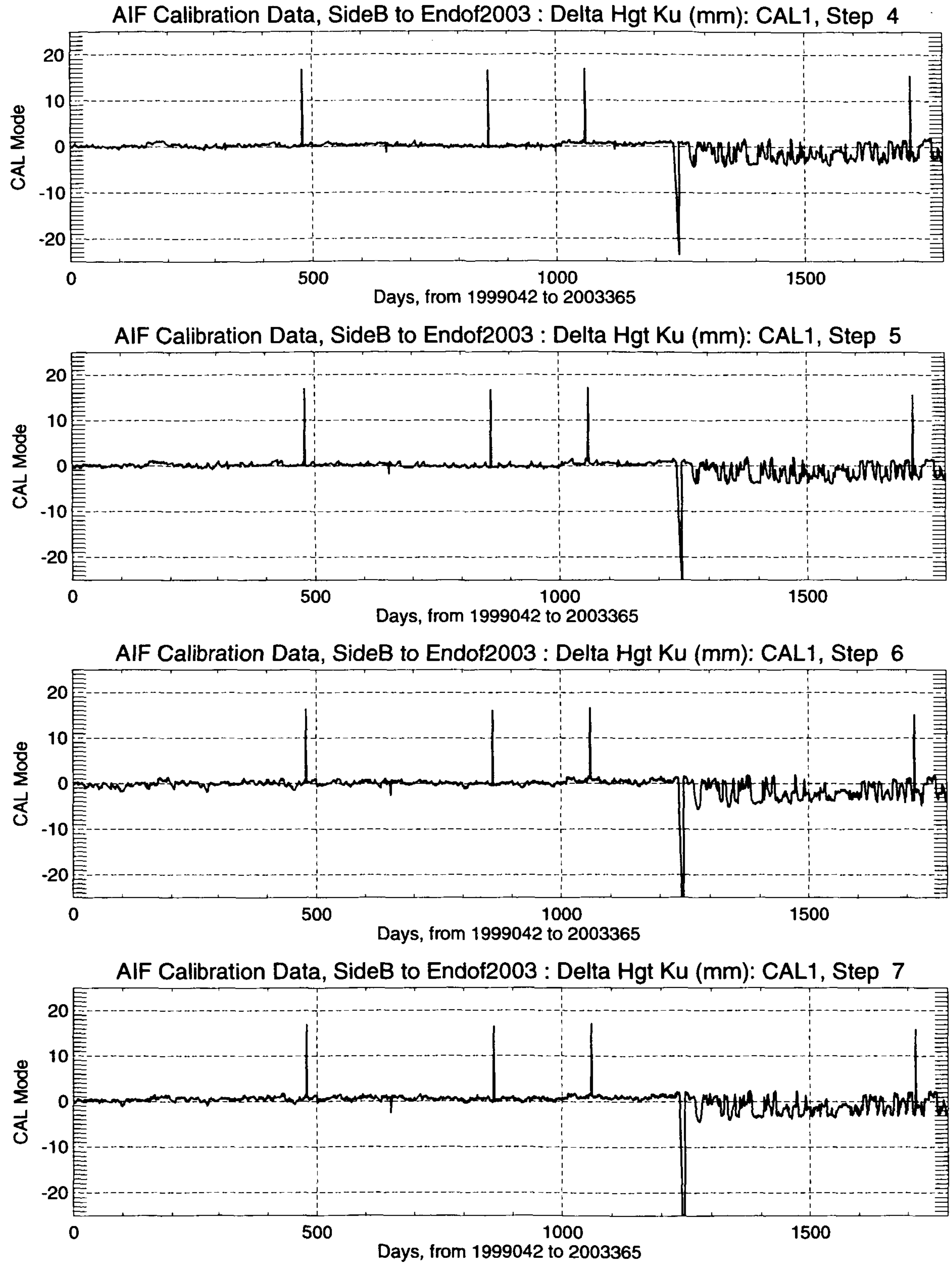


Figure 2-1 Ku-Band Range CAL-1 Results

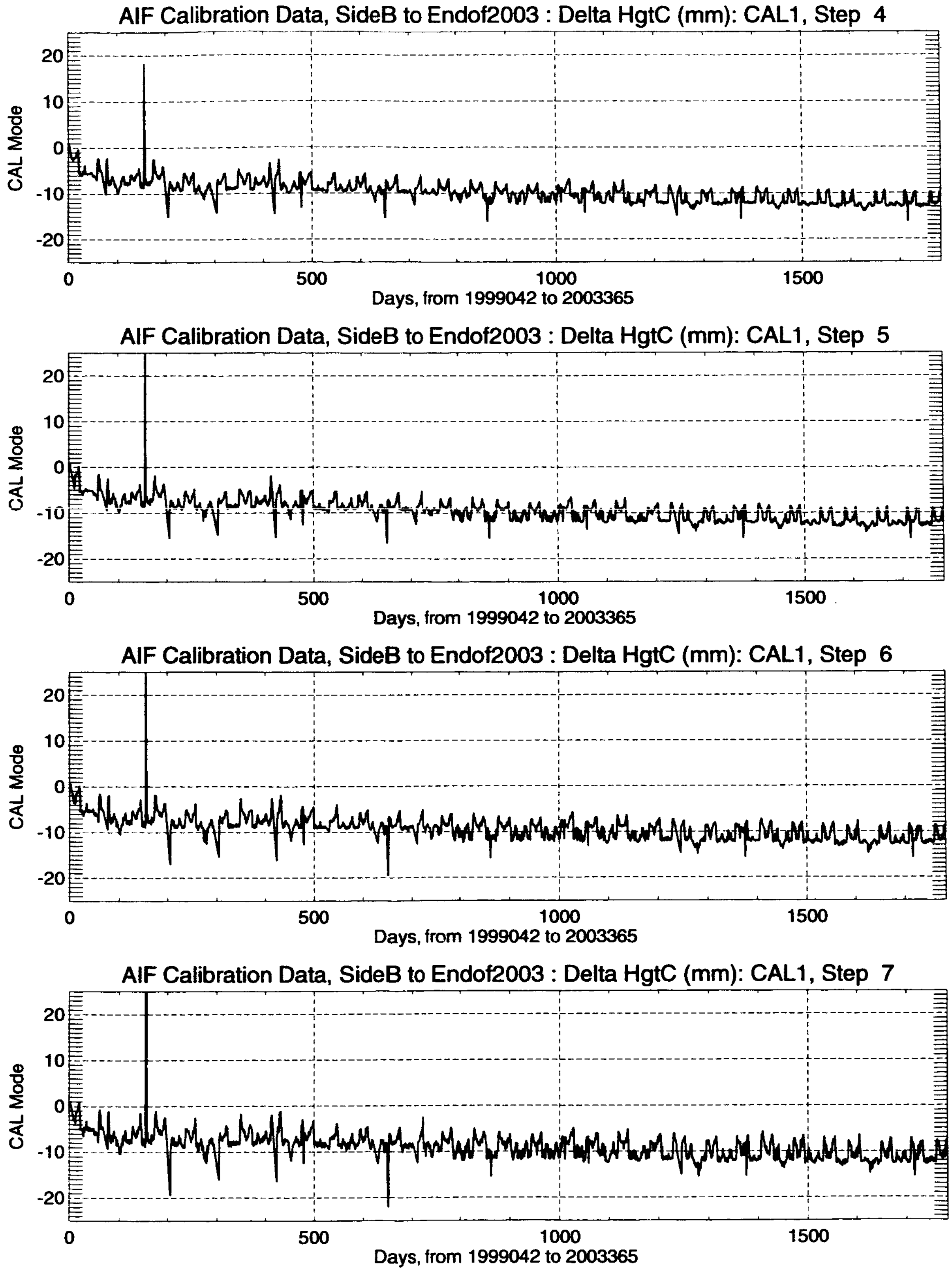


Figure 2-2 C-Band Range CAL-1 Results

2.1.2 AGC Calibrations

2.1.2.1 CAL-1 and CAL-2

The change in Side B Ku-Band AGC since launch is shown in Figure 2-3 "Ku-Band AGC CAL-1 and CAL-2 Results" on page 2-7. CAL-1 steps 4 through 6, plus CAL-2, 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 CAL-1 and CAL-2 Results" on page 2-8. The C-Band AGC gradually decreased only about 0.1 dB since turn-on.

An in-depth analysis of AGC calibrations, including the corrections being applied to the ground processed data, is presented in Section 3.2.

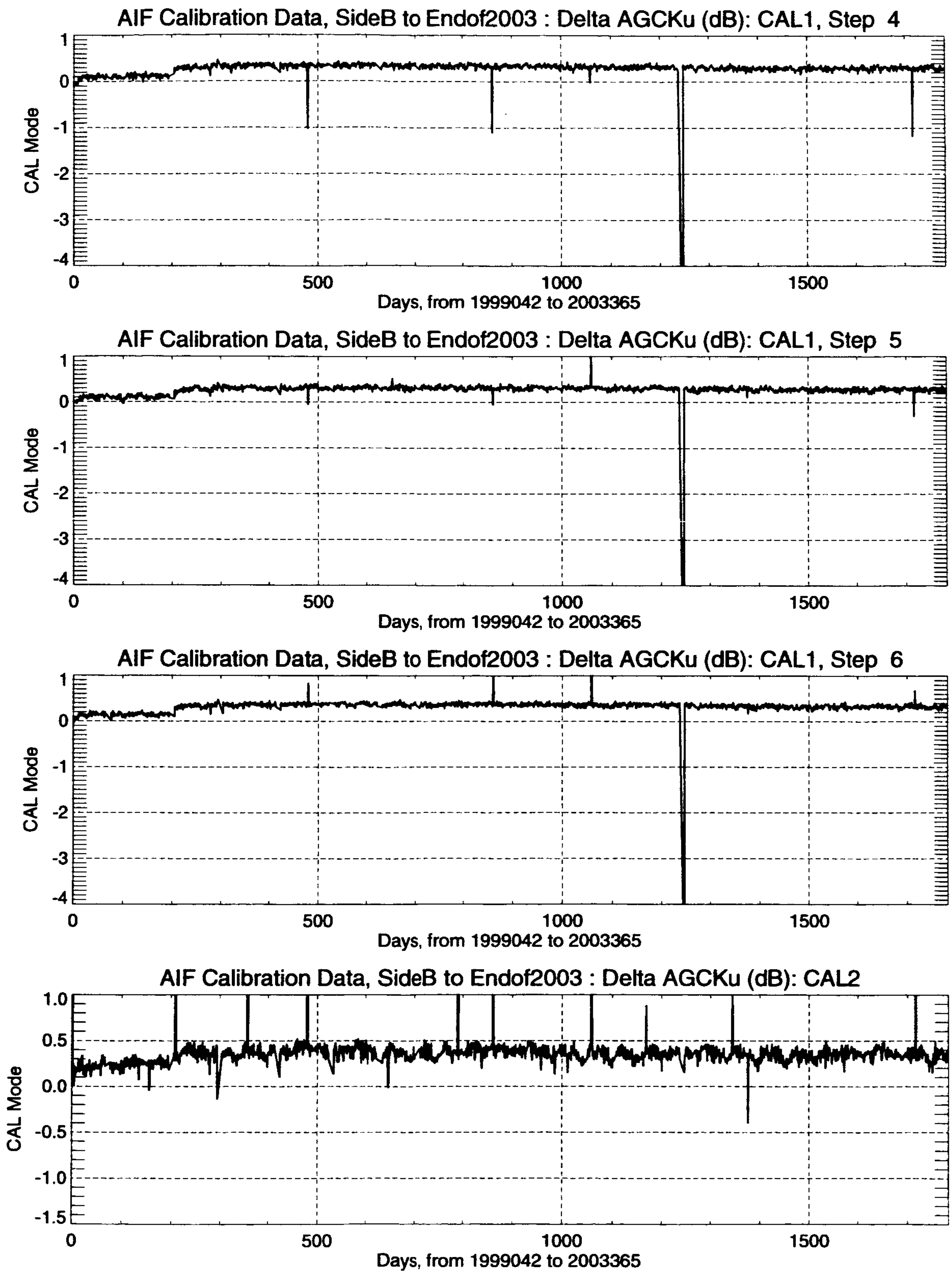


Figure 2-3 Ku-Band AGC CAL-1 and CAL-2 Results

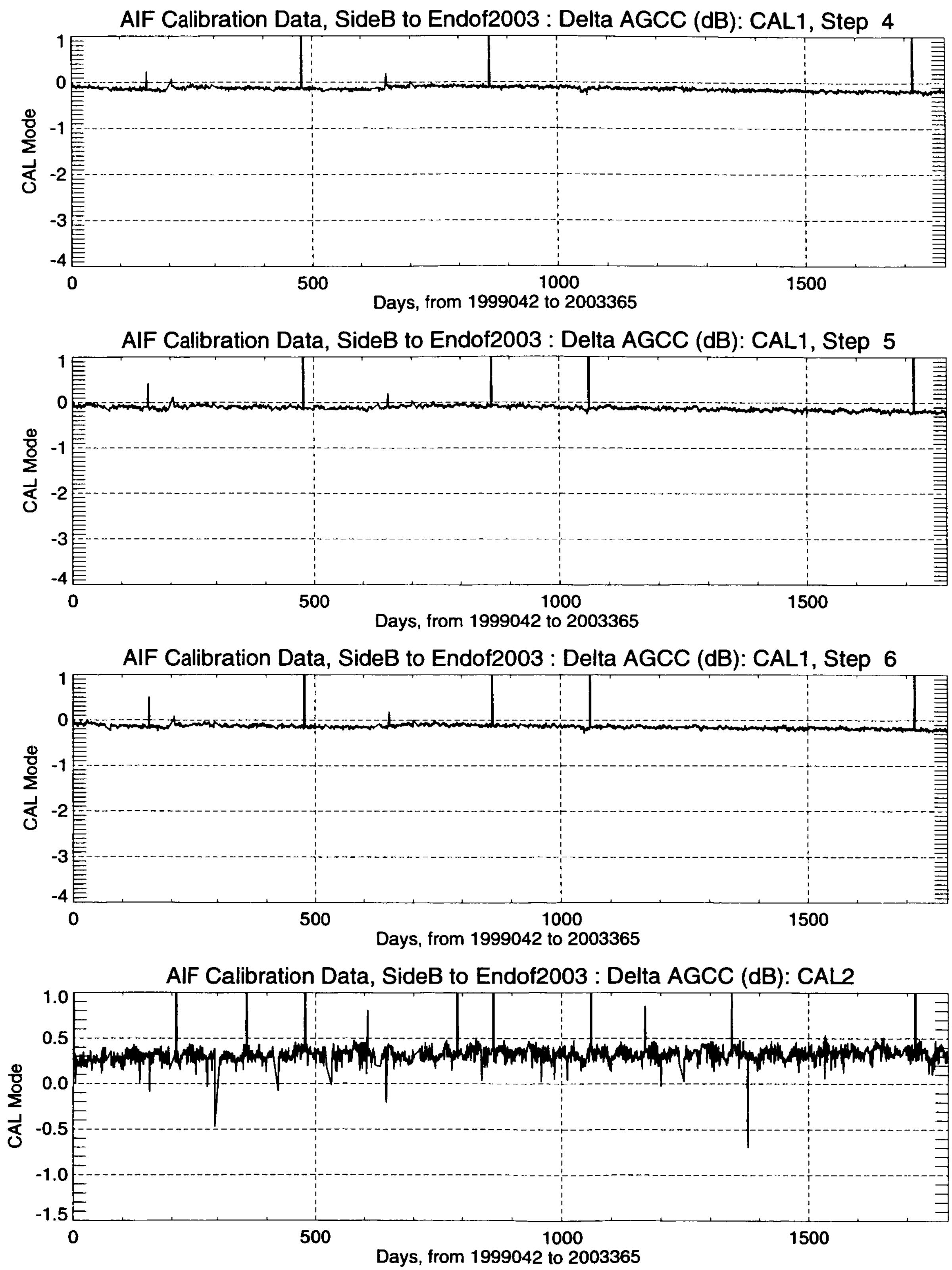


Figure 2-4 C-Band AGC CAL-1 and CAL-2 Results

2.2 Side B Cycle Summaries

The data in the Side B cycle summary plots which follow are extracted from the Geophysical Data Record (GDR) database at WFF. The criteria for TOPEX GDR measurements to be accepted for the WFF database are: 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 is itself the mean of one-minute along-track boxcar averages, after editing. Data are excluded from the averaging process whenever the one-minute-averaged off-nadir angle exceeds 0.12 degree or the averaged Ku-Band sigma0 exceeds 16 dB or whenever the number of non-flagged frames within the one-minute interval is fewer than 45. These edit criteria primarily have to do with eliminating the effects of sigma0 blooms. As a result of this edit, approximately 15% of the database measurements are excluded from the averaging process. This tight editing is part of our effort to ensure that anomalous data are 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 has been more variable between cycles, and the mean ssh has been 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.

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 has generally remained in a band between 10.95 and 11.35 dB, while the C-Band has been in a band between 14.40 and 14.80 dB.

Sigma0 trends are discussed in more detail in Section 3.2.

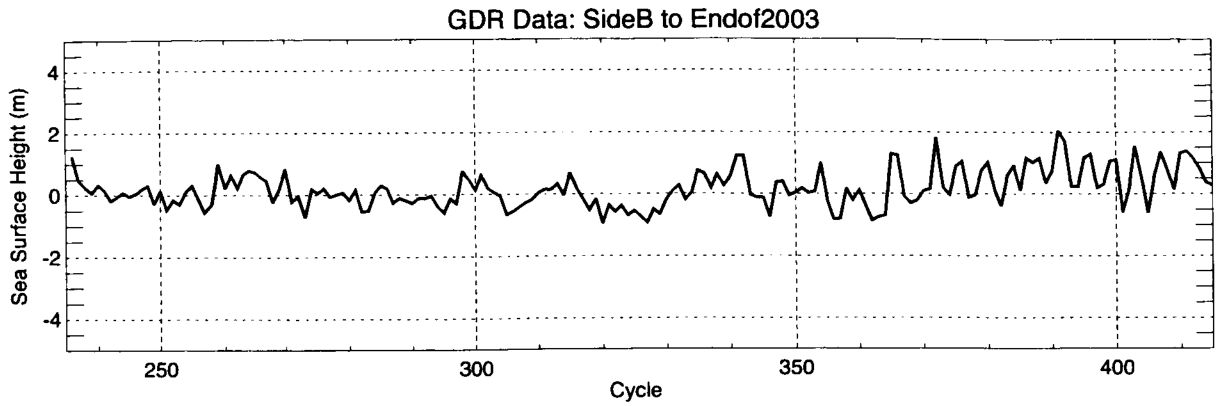


Figure 2-5 Cycle-Average Sea Surface Height in Meters

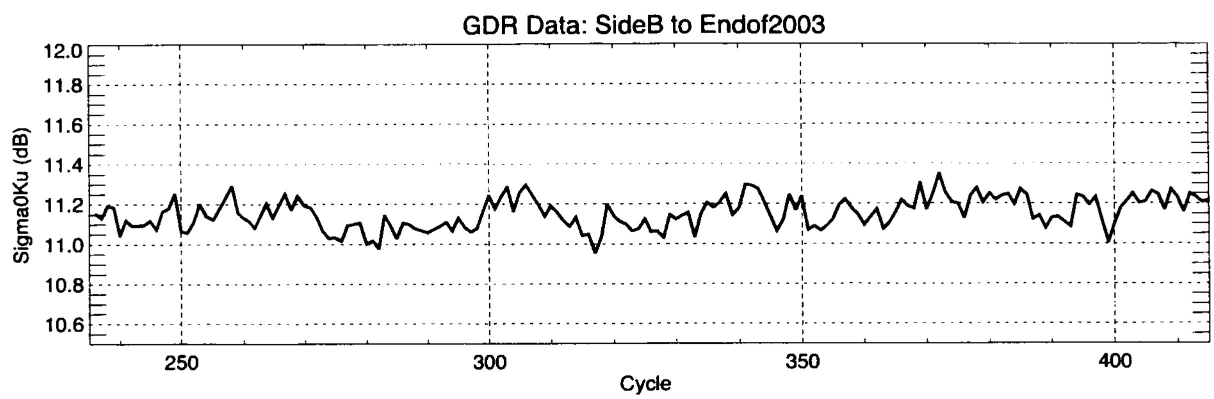


Figure 2-6 Cycle-Average Ku-Band Sigma0 in dB

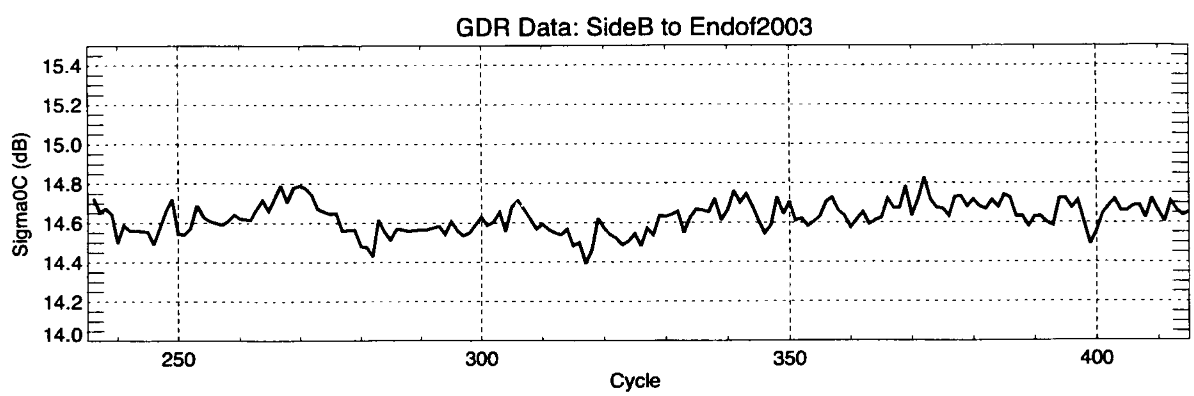


Figure 2-7 Cycle-Average C-Band Sigma0 in dB

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 in later 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 5-1 "JASON/TOPEX Significant Wave Height Comparison" illustrates the comparison of the JASON/TOPEX SWH Ku and SWH C.

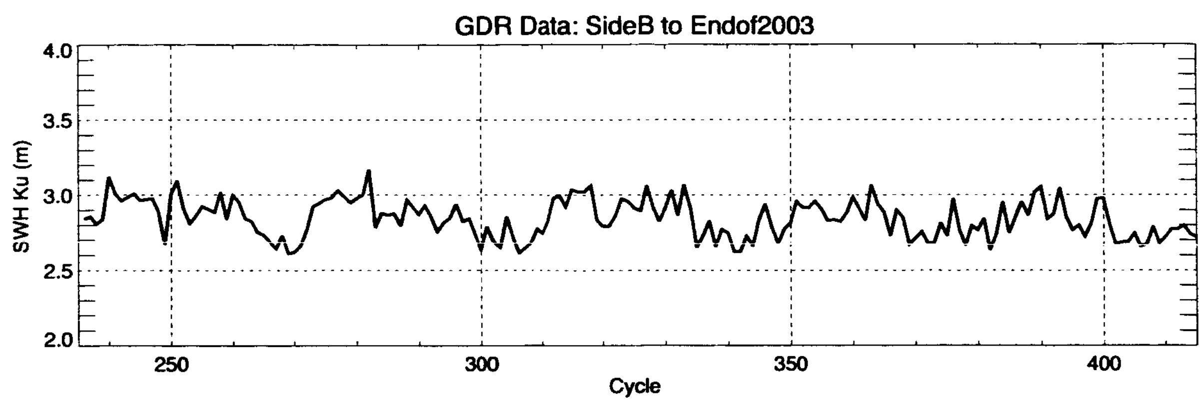


Figure 2-8 Cycle-Average Ku-Band Significant Wave Height in Meters

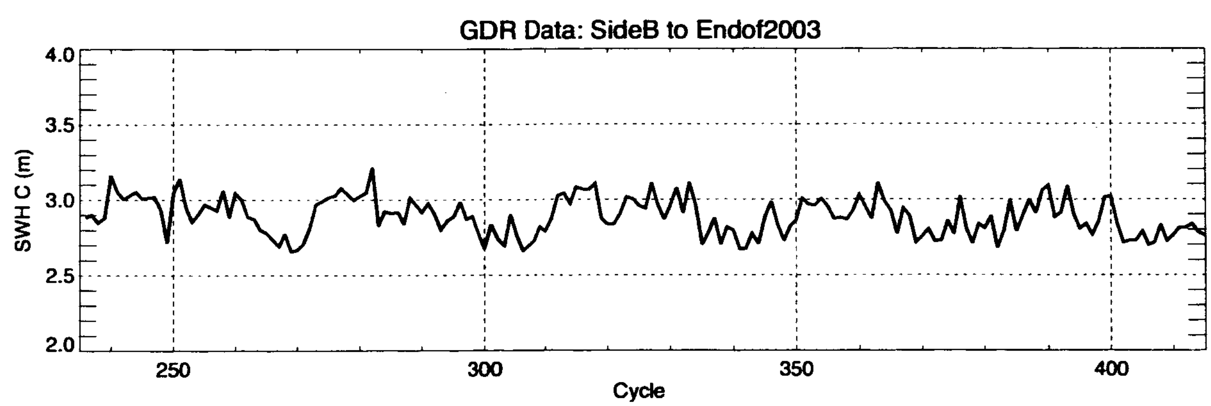


Figure 2-9 Cycle-Average C-Band Significant Wave Height in Meters

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.

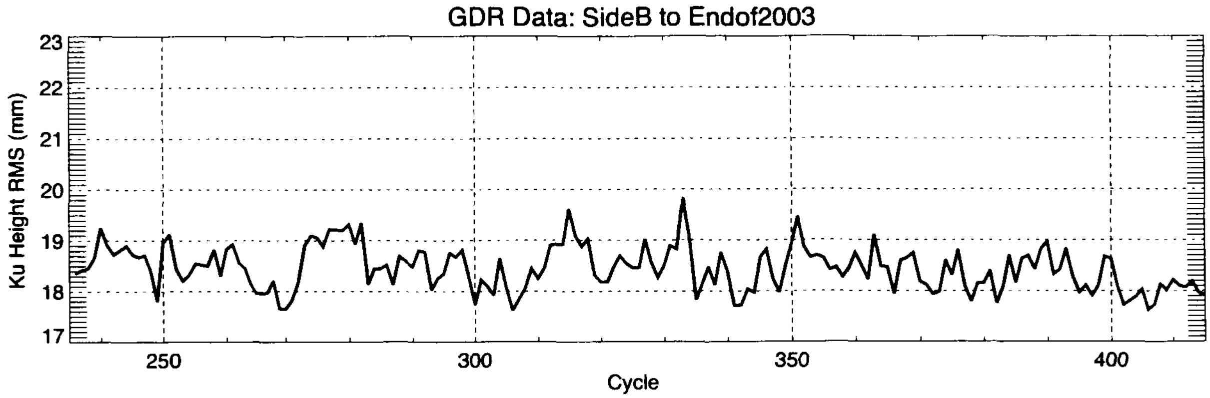


Figure 2-10 Cycle-Average Ku-Band Range RMS in Millimeters

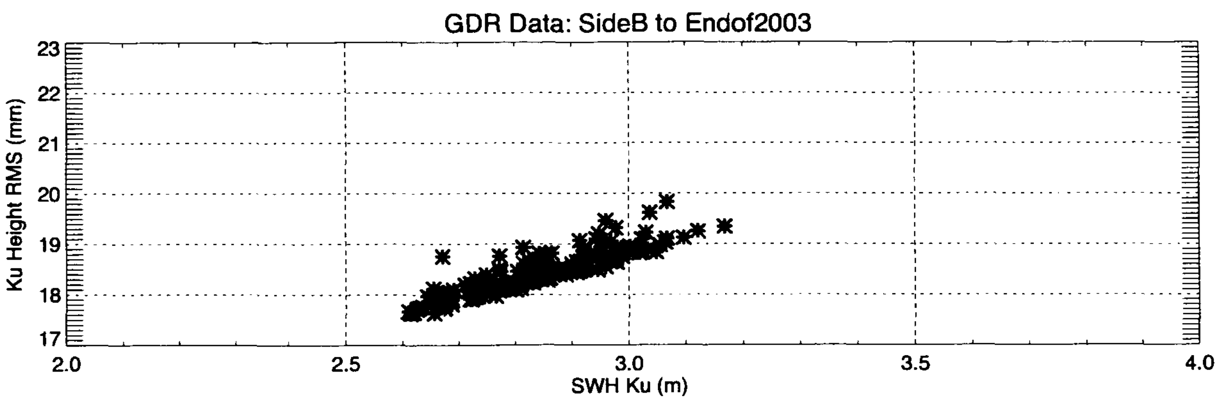


Figure 2-11 Ku-Band Range RMS vs. SWH

2.2.5 Waveform Monitoring

Selected telemetered waveform gates during CAL-2 and STANDBY modes are monitored daily, to discern waveform changes throughout the mission. CAL-2 waveform sets are generally available twice per day, during calibrations. STANDBY waveforms are generally available four times per day, since the altimeter passes 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 are as follows: CAL-2 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 CAL-2 Waveform Sample History" on page 2-14 and in Figure 2-13 "Ku-Band STANDBY Waveform Sample History" on page 2-15 for CAL-2 and STANDBY, respectively. The C-Band waveform history is depicted in Figure 2-14 "C-Band CAL-2 Waveform Sample History" on page 2-16 and in Figure 2-15 "C-Band STANDBY Waveform Sample History" on page 2-17, respectively, for CAL-2 and STANDBY.

The monitored Ku-Band CAL-2 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, have 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 has then remained fairly steady. Gate 69 is continuing to decrease slightly.

The Side B C-Band CAL-2 waveforms samples, shown in Figure 2-14, are similar to the Ku-Band CAL-2 waveforms in that they have varied 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 have an inverse dependence on temperature, and have each experienced increases shortly after turn-on. Gate 69 continues its decrease, accompanied by an increase in variability commencing around day 1300.

In Figure 2-14, there are waveform spikes at the labeled days of 210, 359, 480, 800, 861 and 1722. The reasons for these spikes are posted in the "Side B Key Events", section 2.3, Table 2-2. They are: 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 1722 (2003-303) Improper SEU recovery.

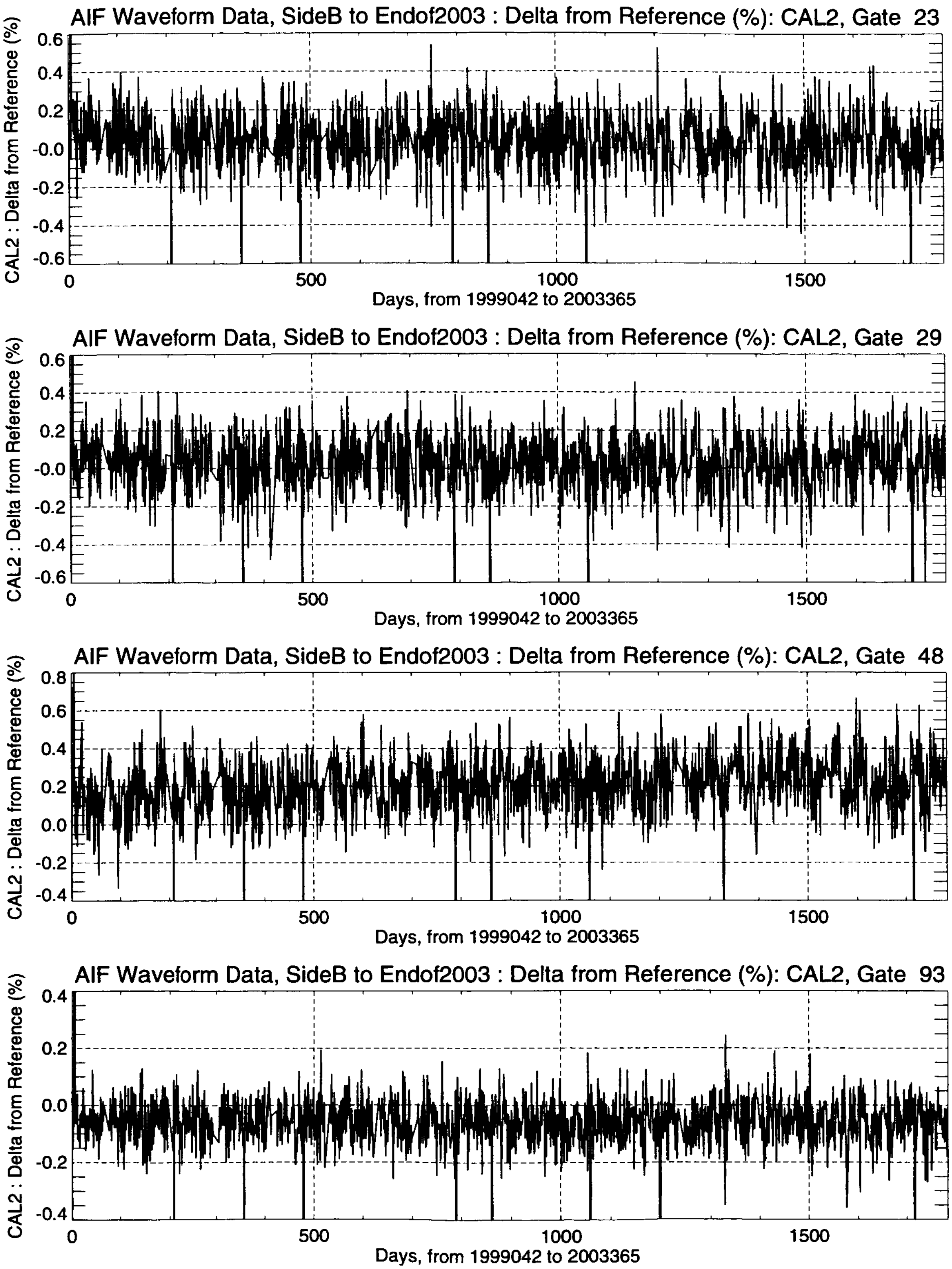


Figure 2-12 Ku-Band CAL-2 Waveform Sample History

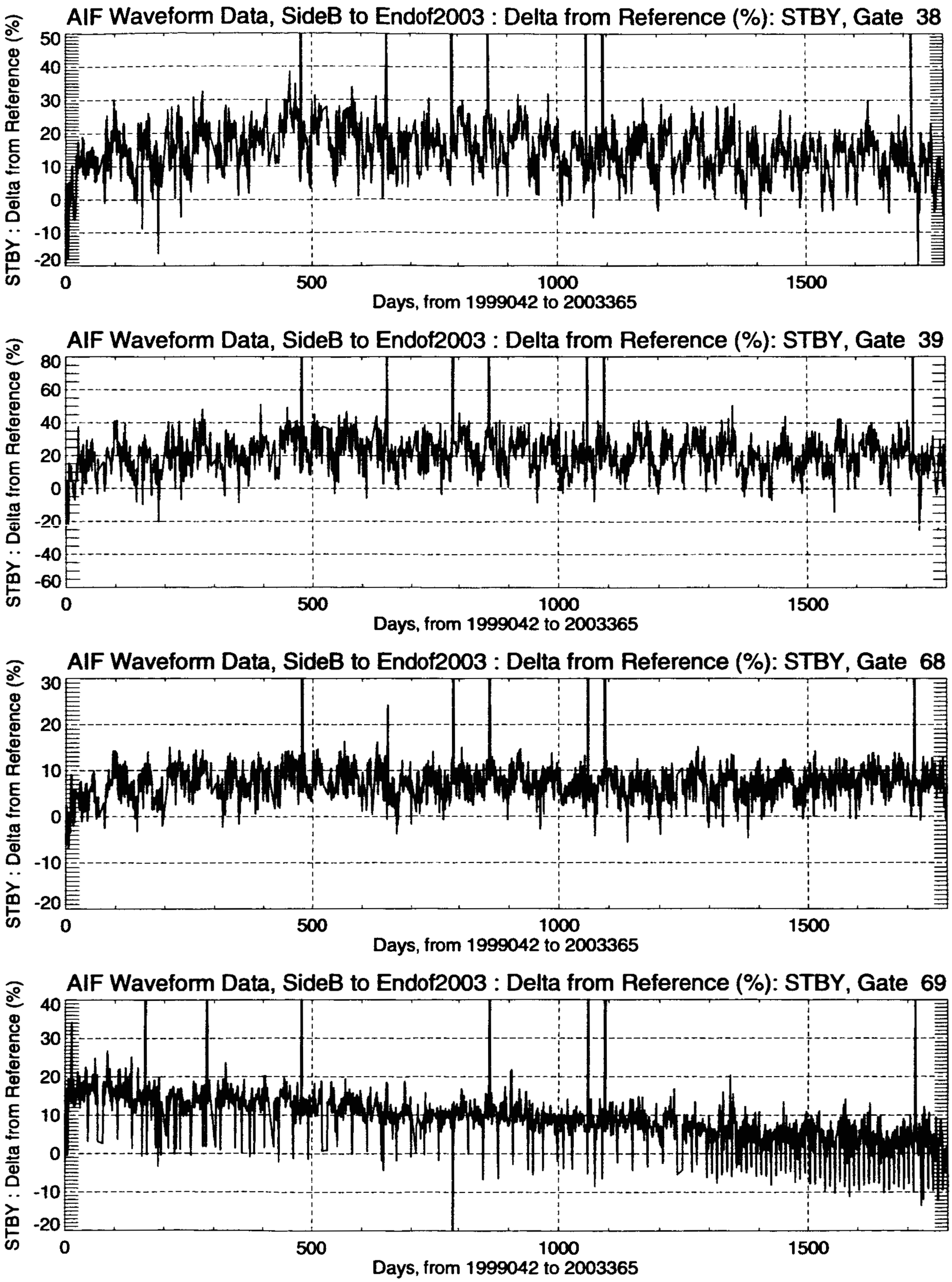


Figure 2-13 Ku-Band STANDBY Waveform Sample History

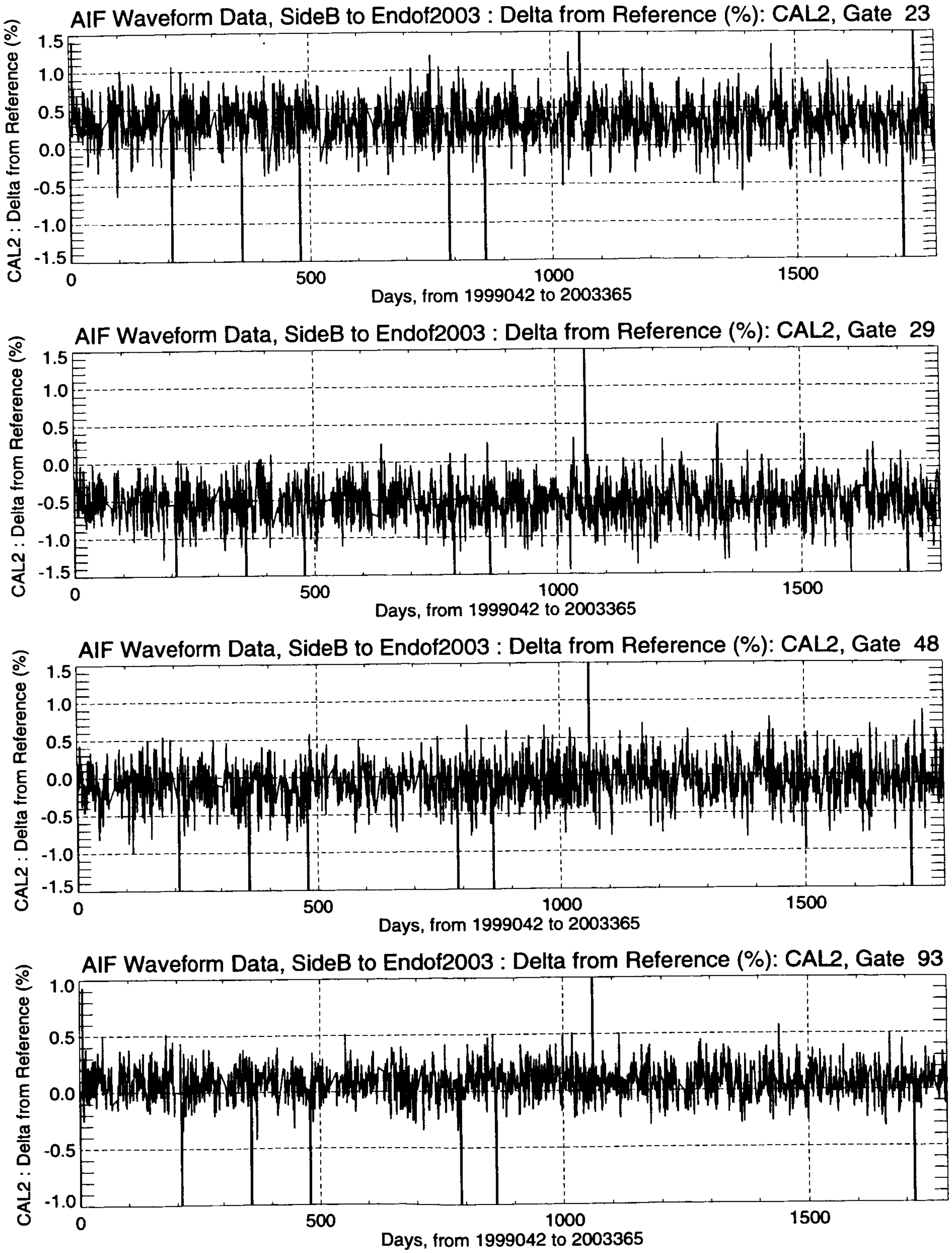


Figure 2-14 C-Band CAL-2 Waveform Sample History

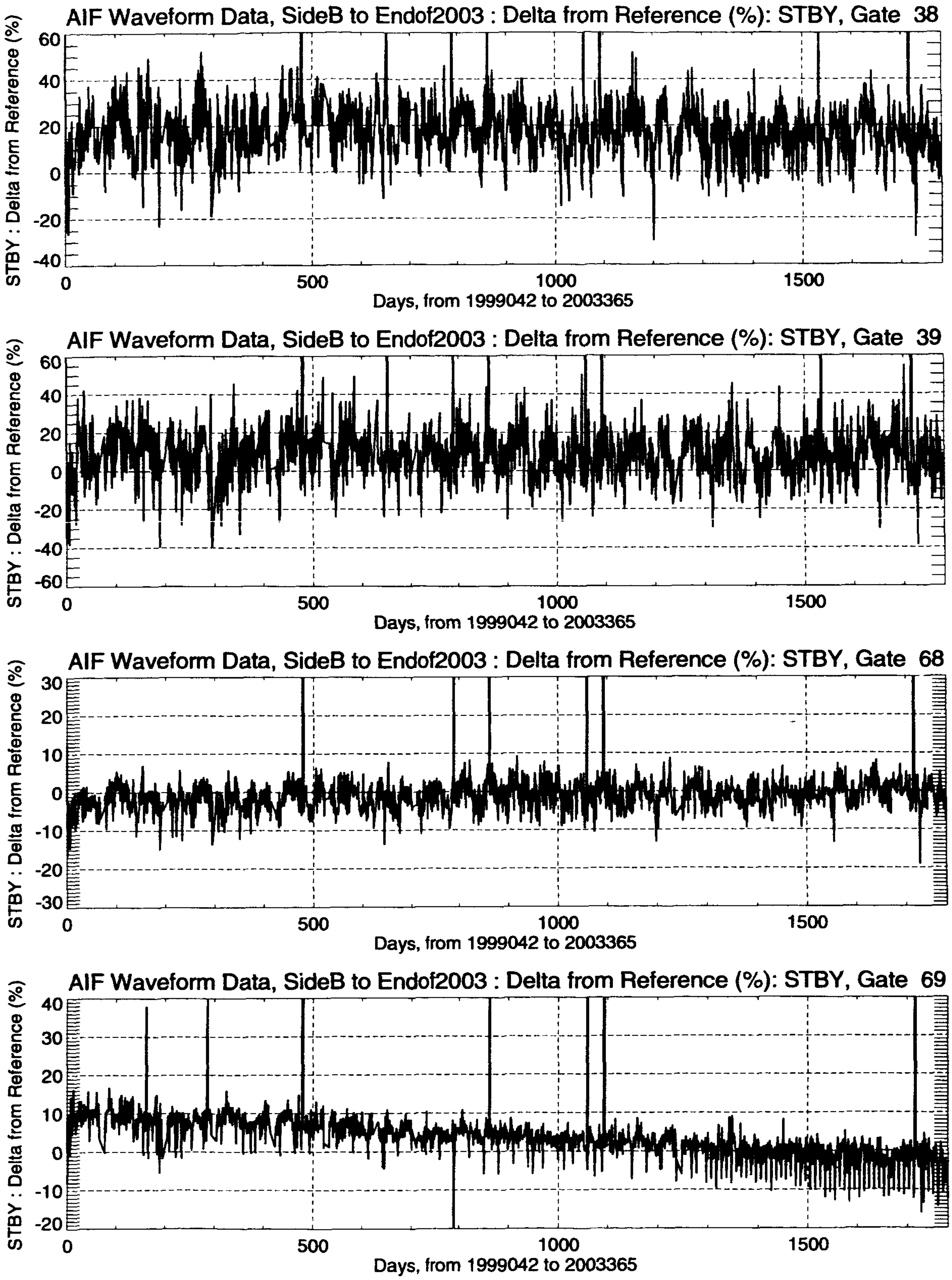


Figure 2-15 C-Band STANDBY Waveform Sample History

2.2.6 Engineering Monitors

Altimeter temperatures, voltages, powers and currents continue to be monitored. The system remains very stable, with no significant changes 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 temperatures of all 26 internal thermistors continued to be within the design temperature range and, except for the DCG Gate Array, are 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 2-19.

As noted in previous years' assessment reports, the DCG Gate Array temperature is about 30 degrees higher than that experienced during pre-launch testing. Further, the temperature has exhibited a slow rise since Side B turn-on of about 0.5 degree per year, as initially noted by Beth Fabinsky of JPL. A lifetime thermal analysis of a similar DCG Gate Array unit indicates there still should be no great concern.

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 is applied to the thermistor circuits.

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 2000 histories are also shown in Figure 2-16 "Engineering Monitor Histories" on page 2-19.

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 has decreased about 0.05 milliamperes.
- The C-Band Transmit Power has decreased approximately 1.7 watts since turn-on.
- There has been a gradual decrease in the CSSA Bus current level; the level has decreased 0.10 amp since turn-on.

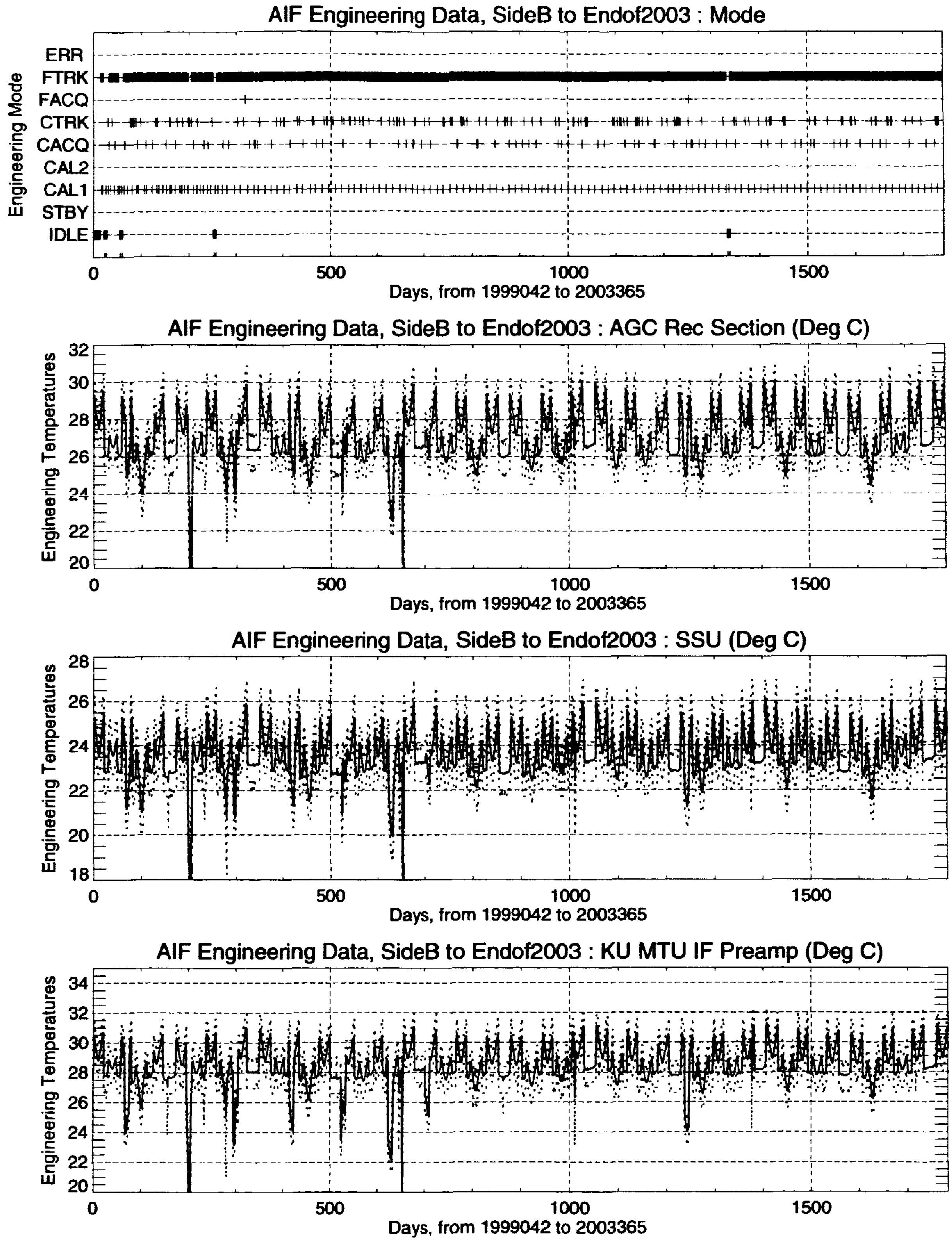


Figure 2-16 Engineering Monitor Histories

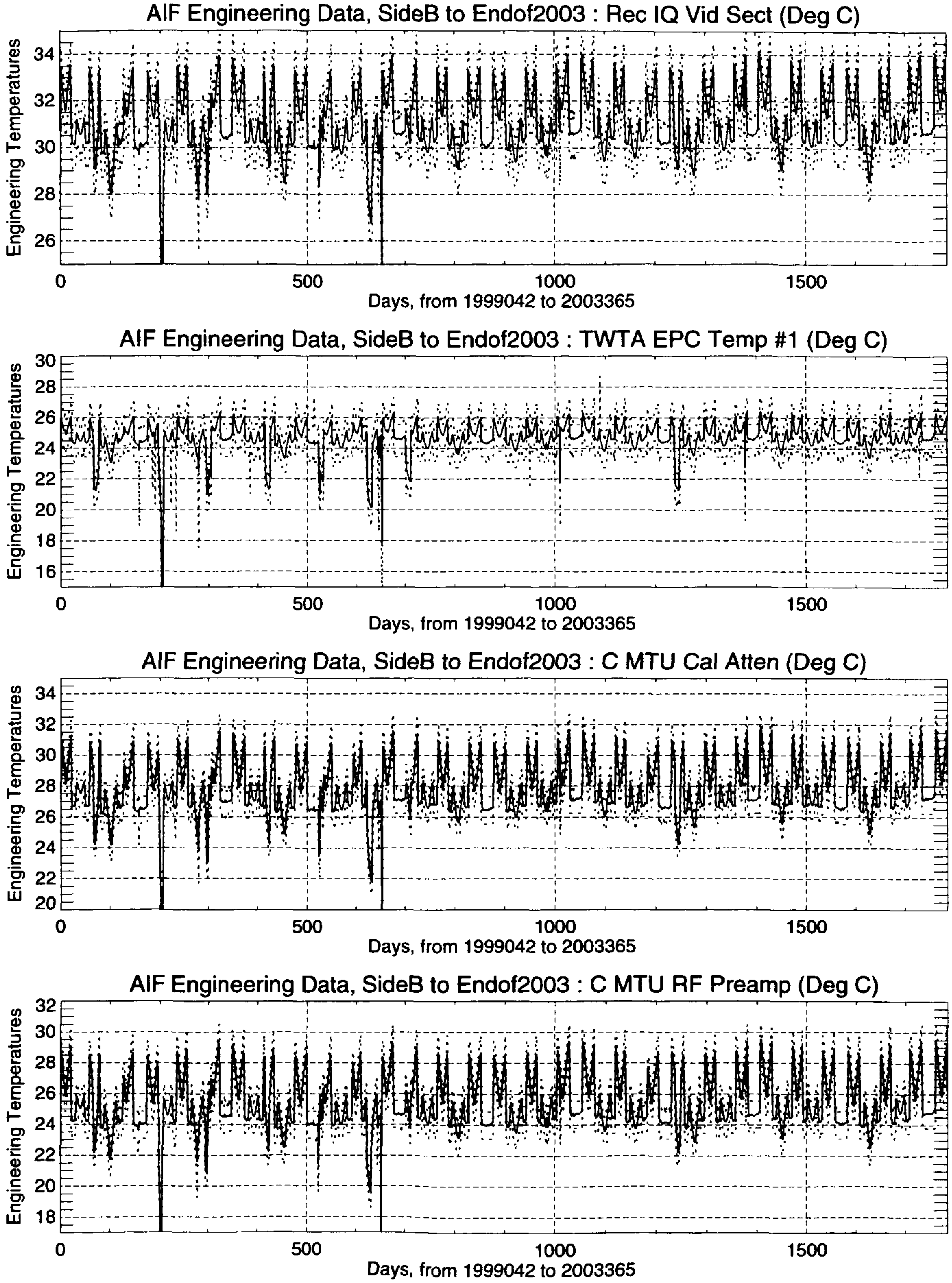


Figure 2-16 Engineering Monitor Histories (Continued)

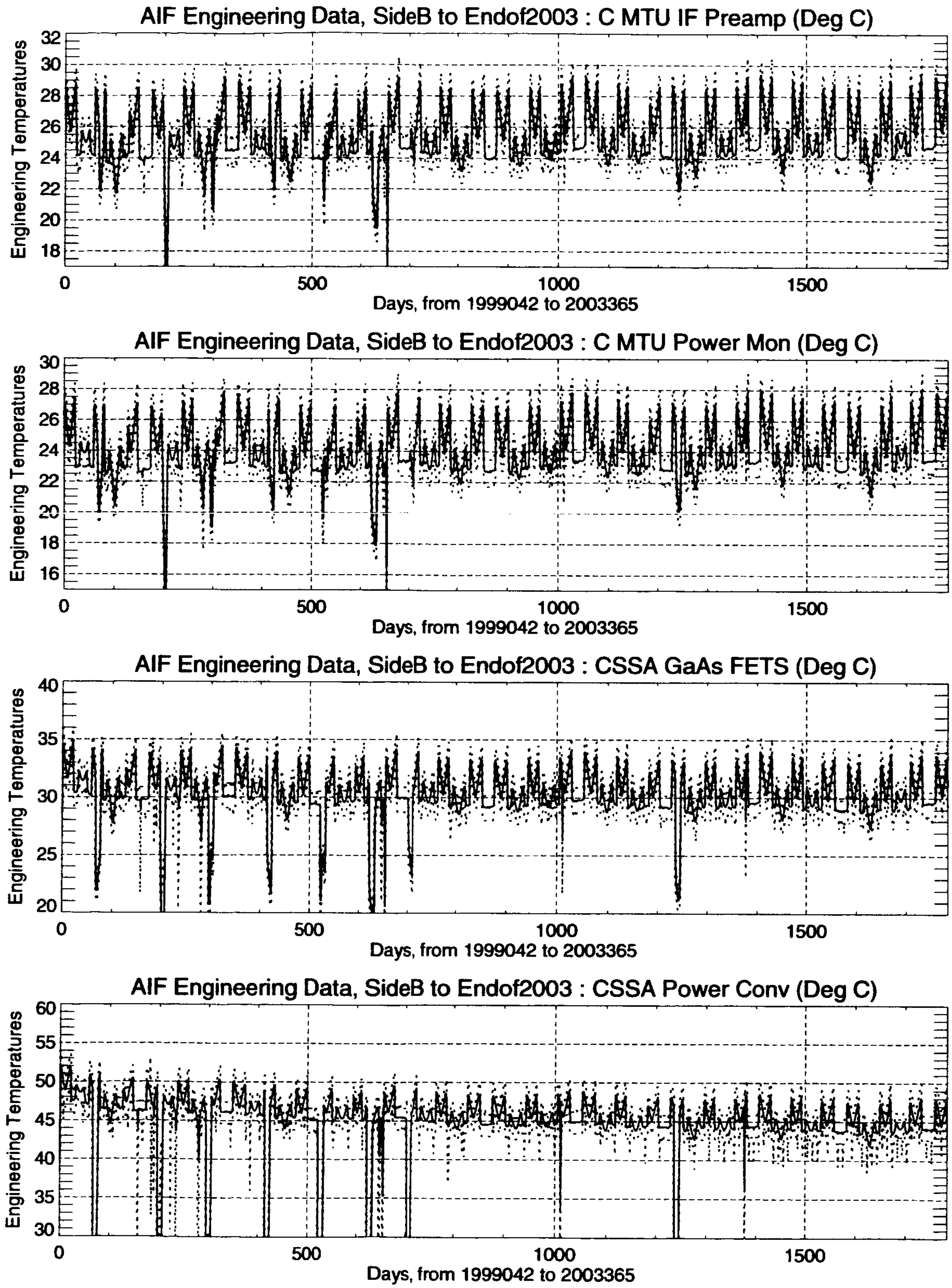


Figure 2-16 Engineering Monitor Histories (Continued)

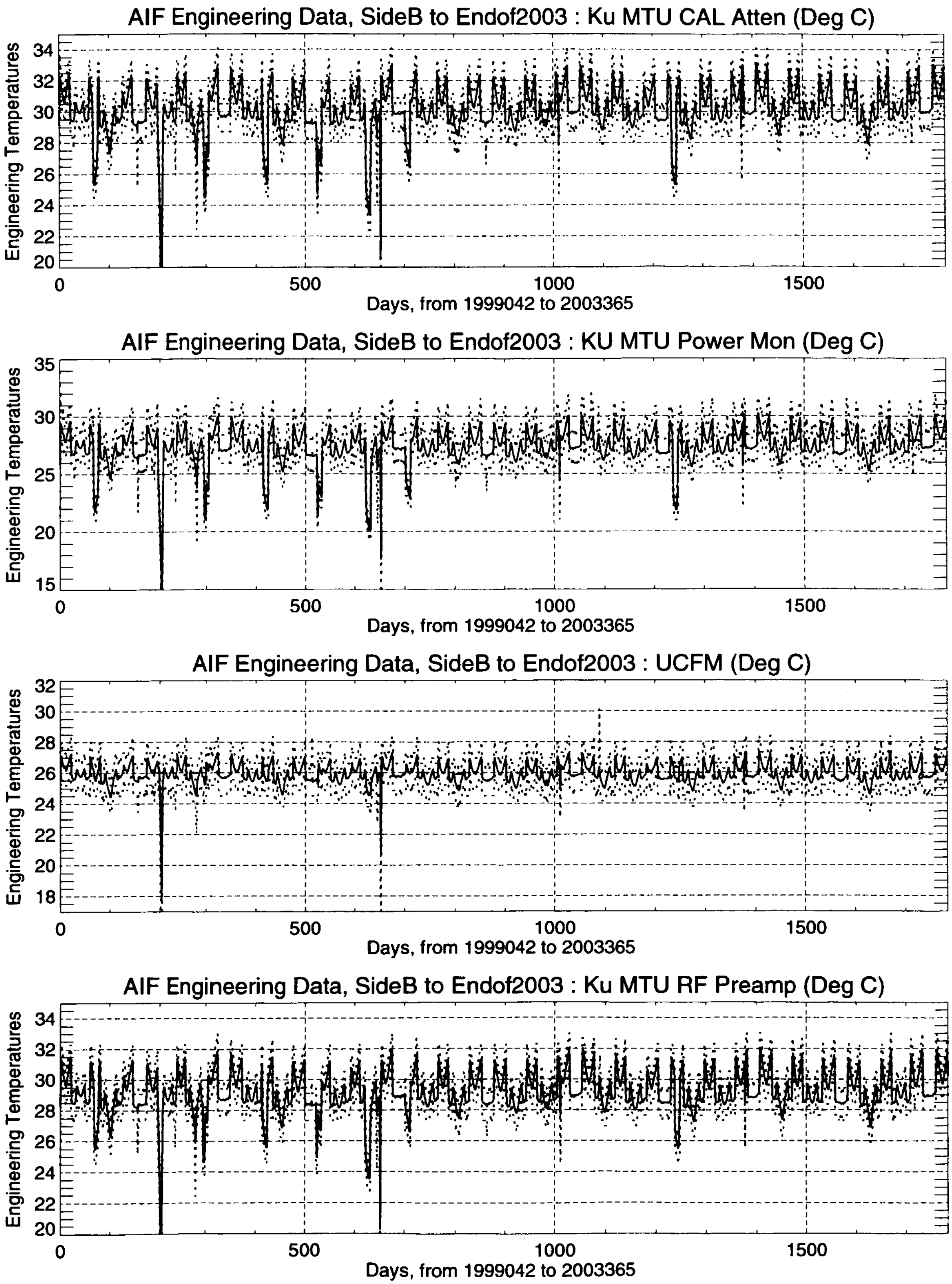


Figure 2-16 Engineering Monitor Histories (Continued)

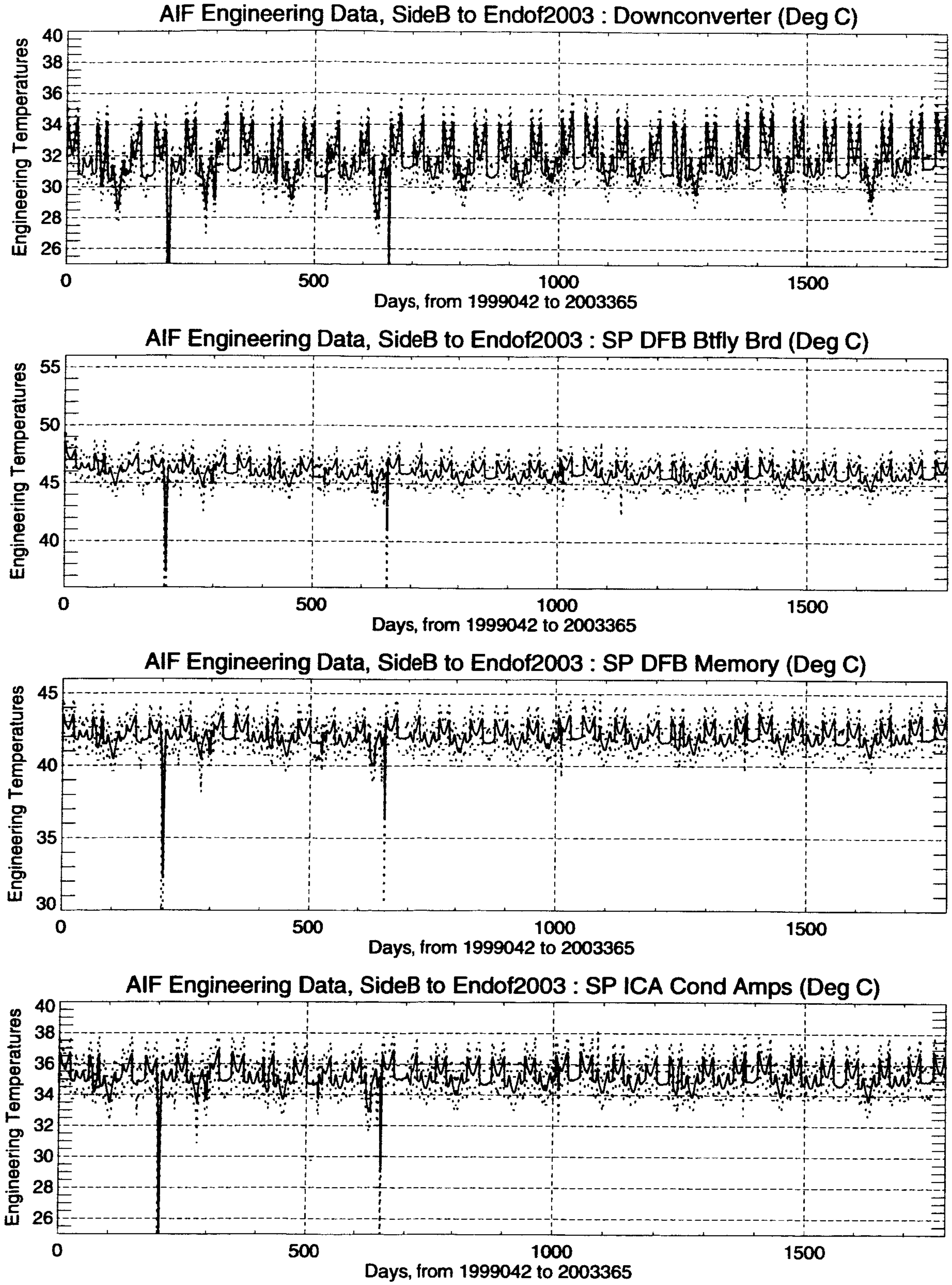


Figure 2-16 Engineering Monitor Histories (Continued)

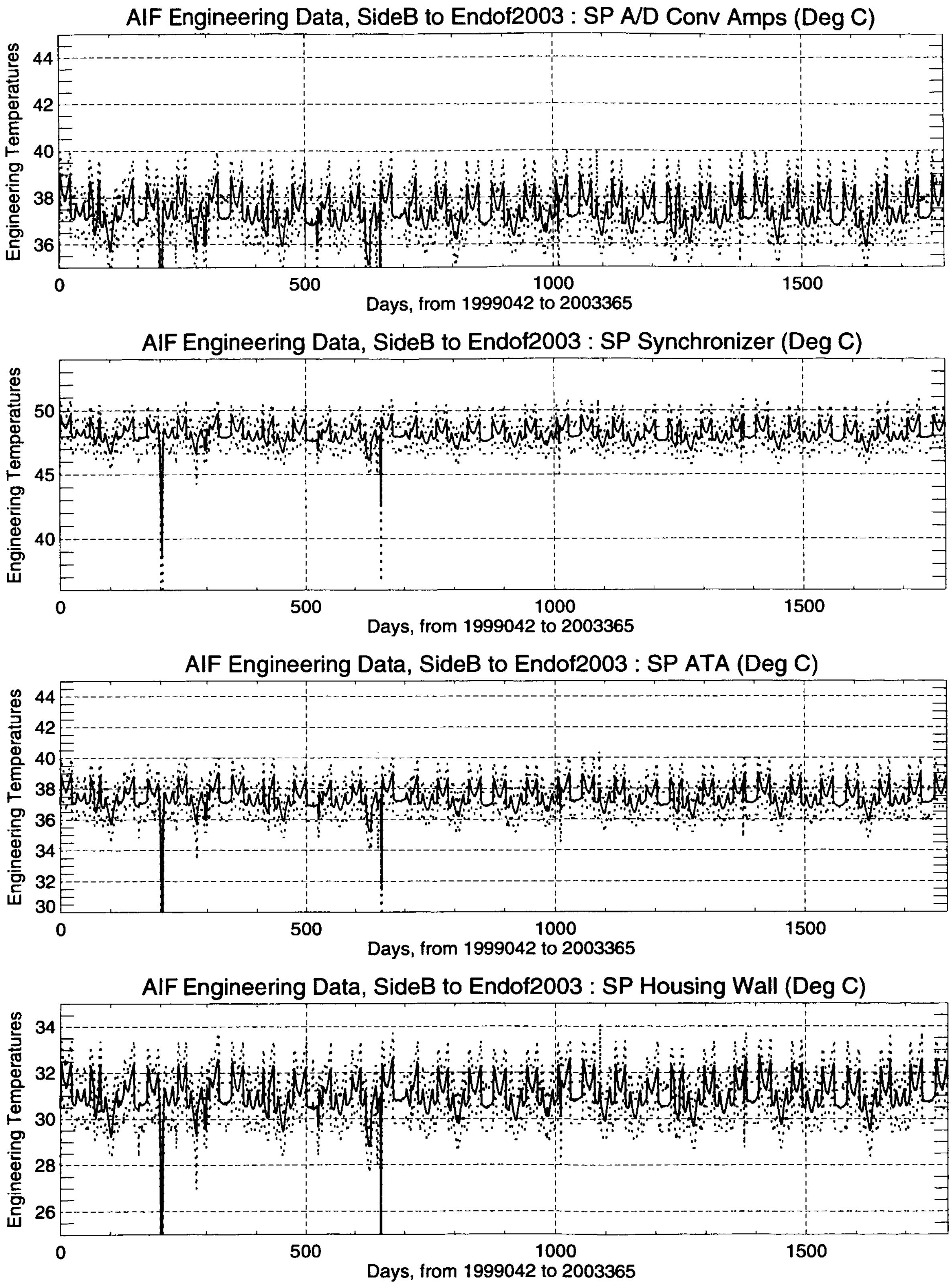
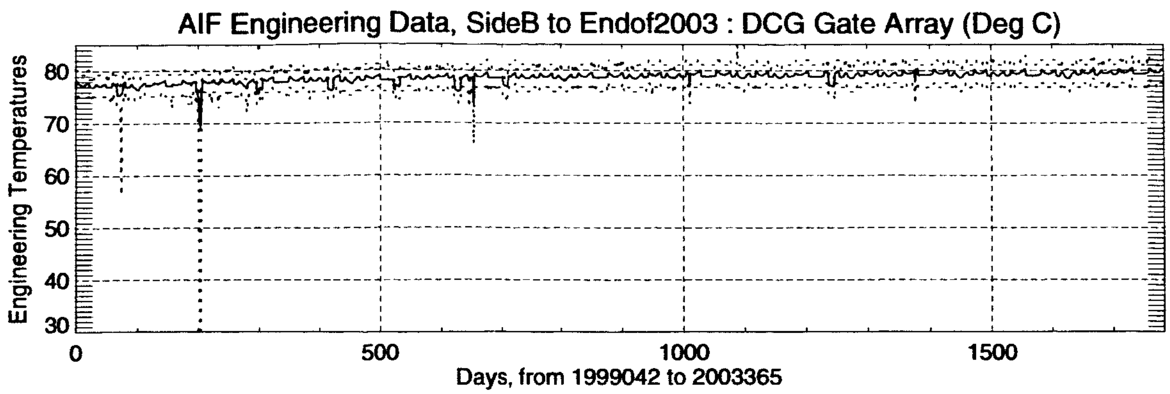
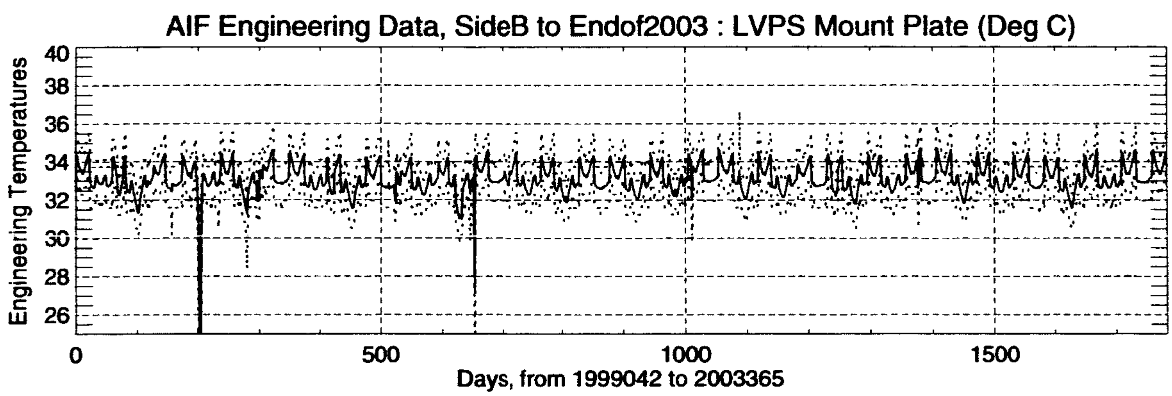
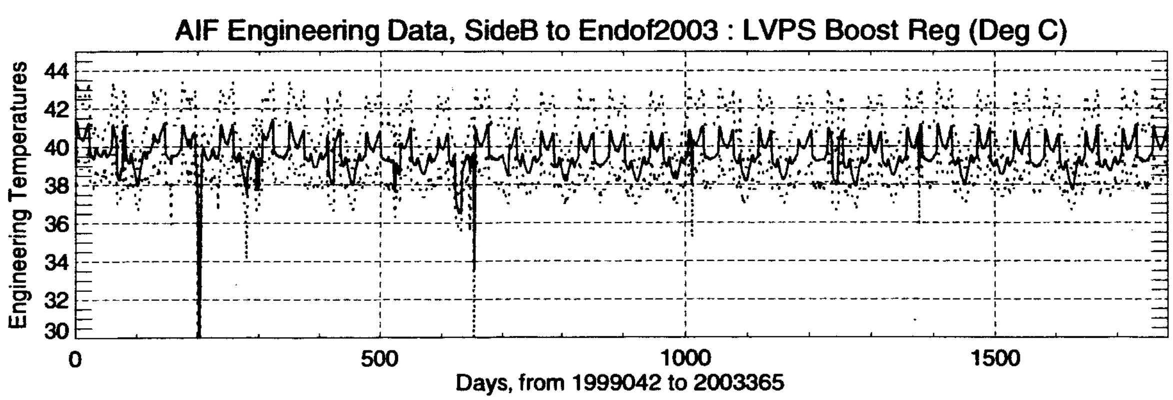


Figure 2-16 Engineering Monitor Histories (Continued)







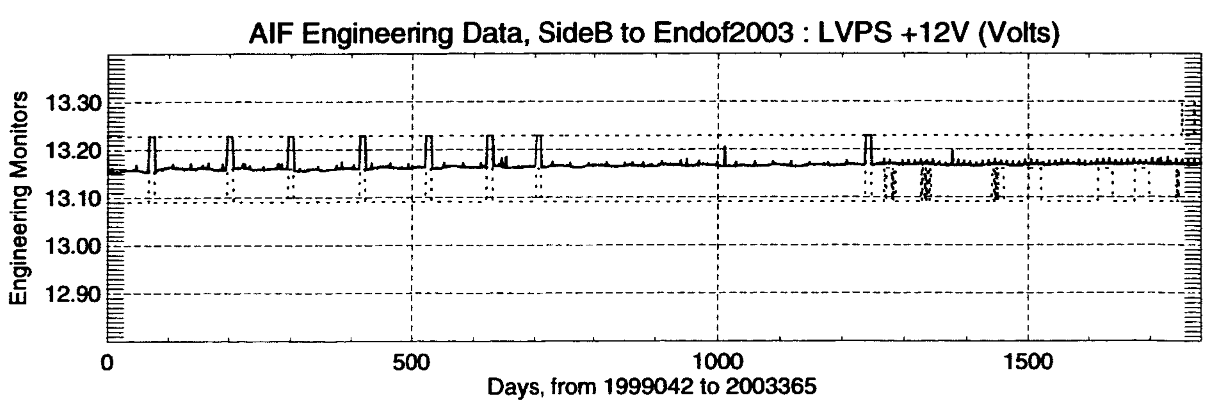


Figure 2-16 Engineering Monitor Histories (Continued)

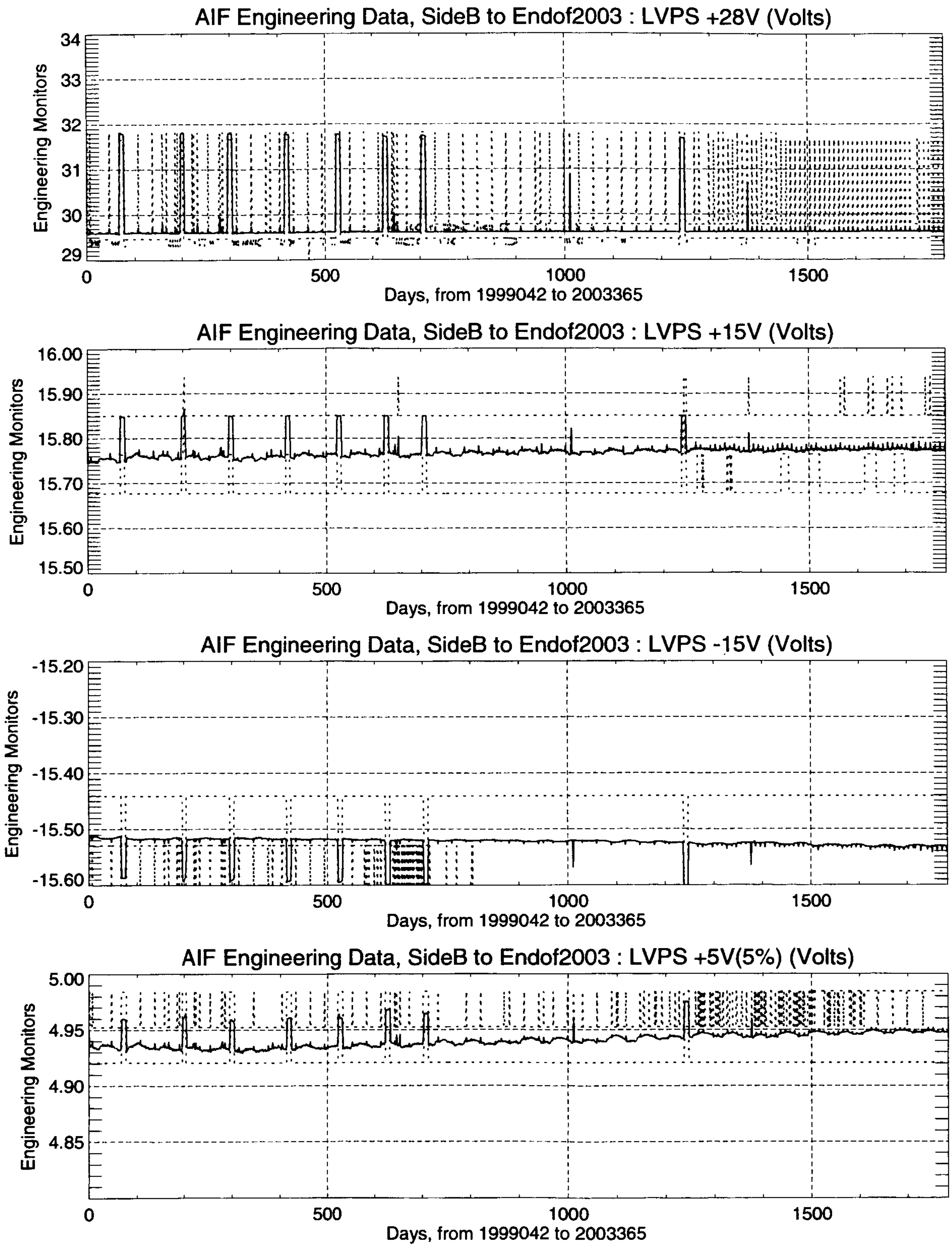


Figure 2-16 Engineering Monitor Histories (Continued)

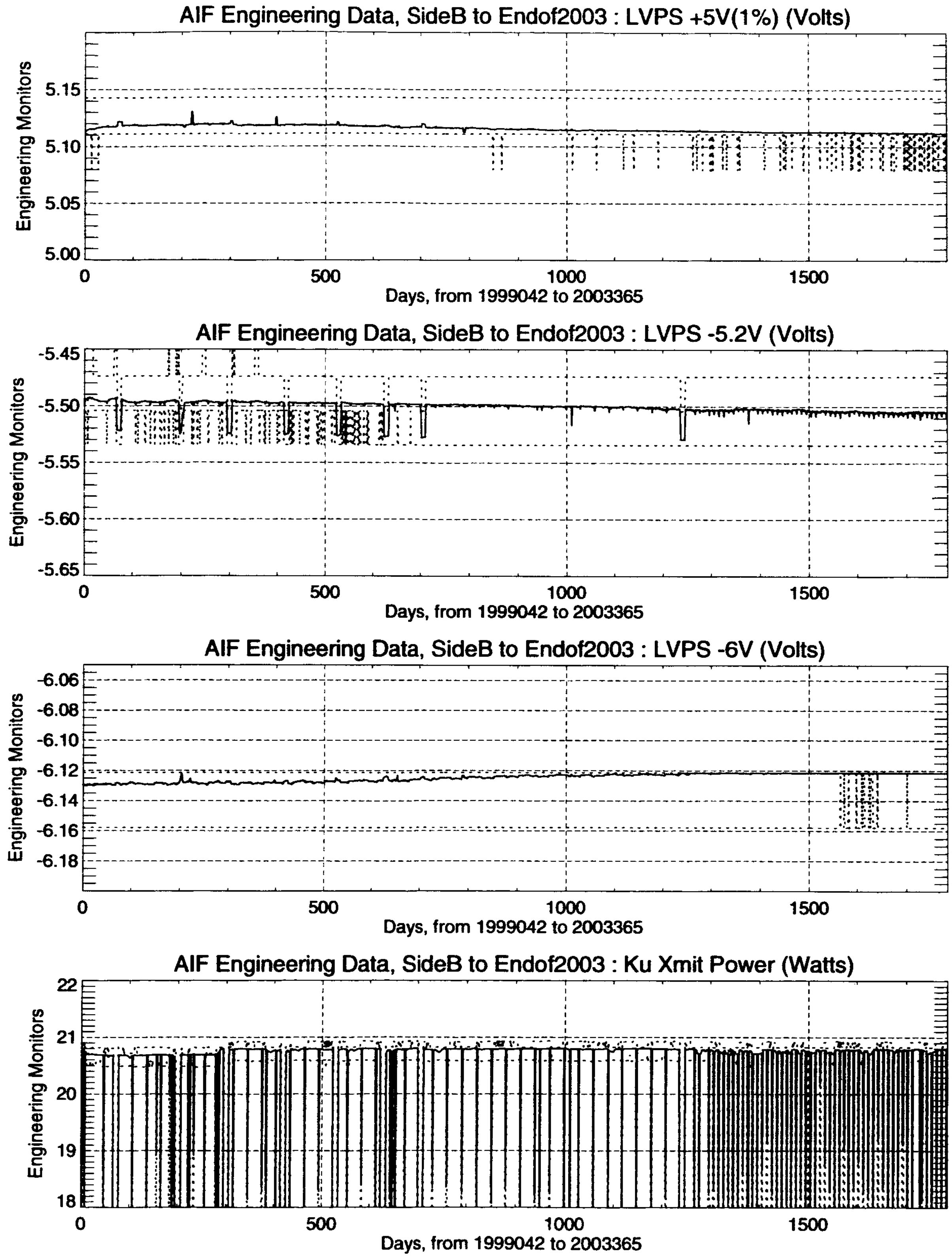
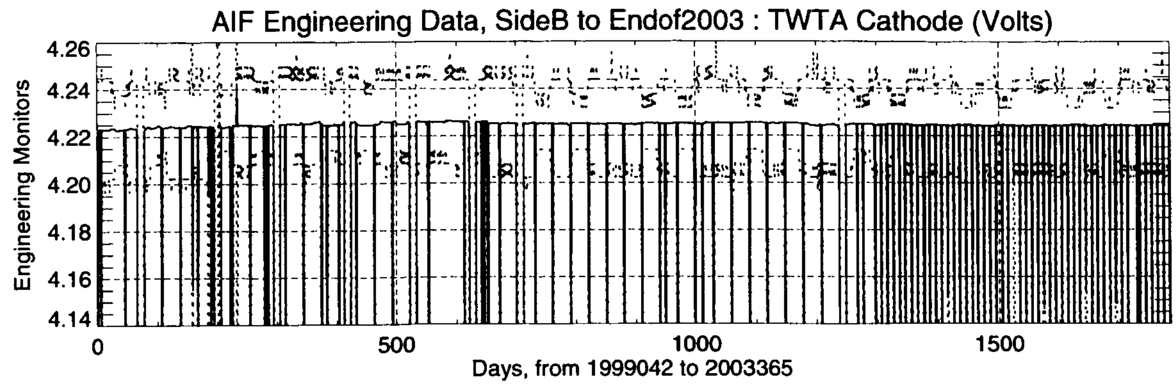
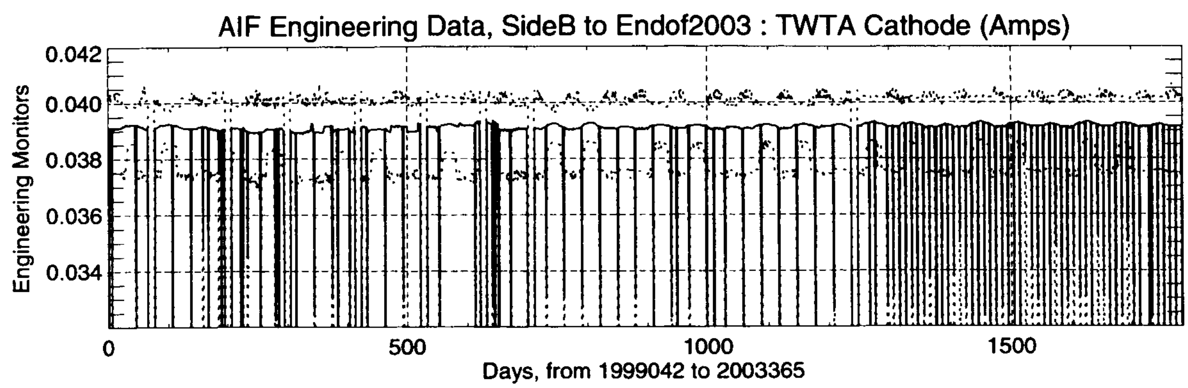
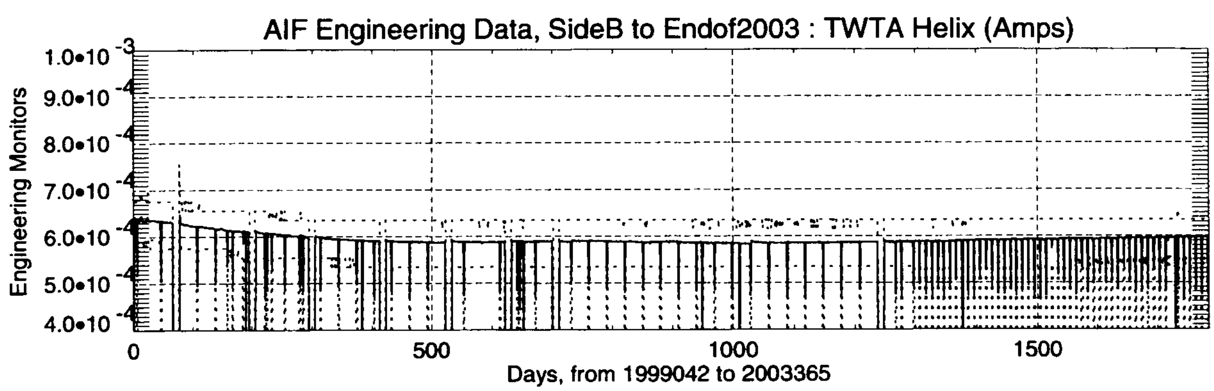


Figure 2-16 Engineering Monitor Histories (Continued)







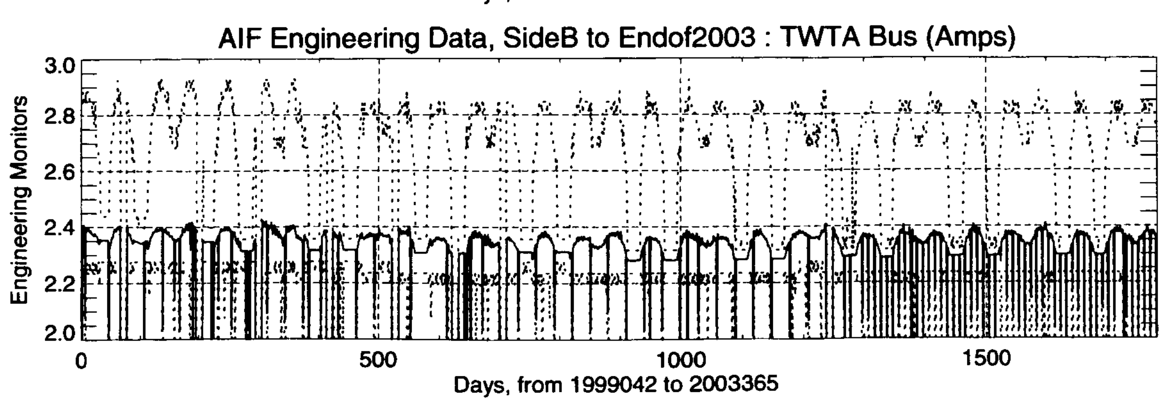


Figure 2-16 Engineering Monitor Histories (Continued)

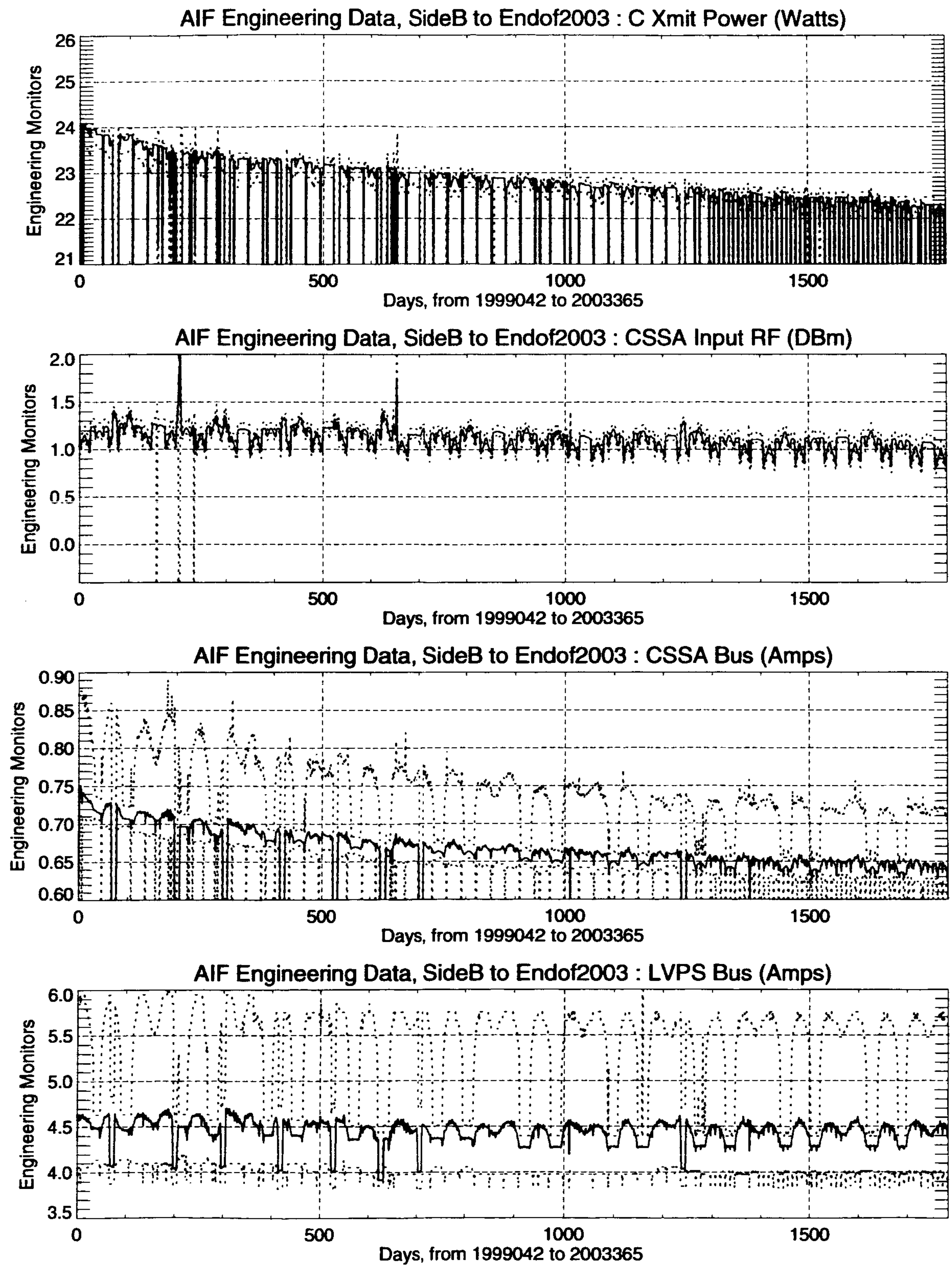


Figure 2-16 Engineering Monitor Histories (Continued)

2.2.7 Single Event Upsets

There have been a total of 269 Single Event Upsets (SEUs) from the initial turn-on of Side B to the end of 2003, an average of one SEU per 6.6 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. This has been in the South Pacific area. The dots in Figure 2-17 denote the locations of normal SEU occurrences, while the diamonds indicate that the SEU was abnormal.

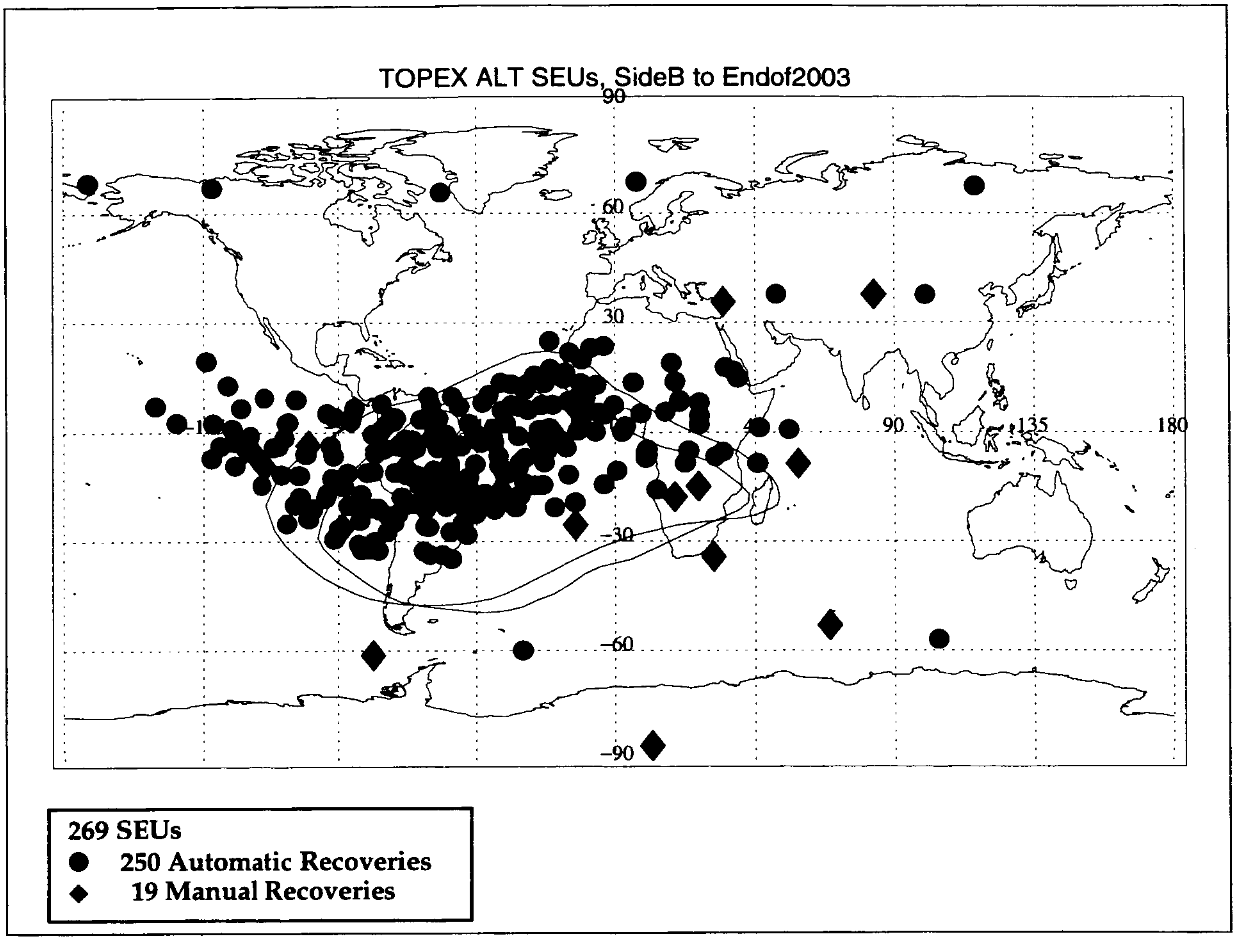


Figure 2-17 Locations of SEU Occurrences

The altimeter processor automatically recovered from 250 of the SEUs; the other 19 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 January 1, 2004, there have been a total of 29 anomalous Side B resets (the 19 manual resets plus 10 additional abnormal automatic resets). Table 2-1 lists the dates of these 29 SEUs, along with the type of on-board reset and the duration of the effect on the data.

Regarding the three abnormal automatic resets in 2003:

- Day 2003-083 - The waveforms were not updating and a range sweep was processed. The altimeter reset itself.
- Day 2003-303 - The SEU reset resulted in a corrupted science spare word. A memory reload corrected the problem. The altimeter science data, in the interim between the SEU and the memory reload, was apparently not affected.
- Day 2003-363 - The waveforms were not updating and a range sweep was processed. The altimeter reset itself.

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
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

Table 2-1 Anomalous Single Event Upsets (Continued)

Year	Day	Duration (Hr)	Reset Type	Type SEU
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
		Total = 63.1 Hrs		

2.3 Side B Key Events

The key events for TOPEX Altimeter Side B since its on-orbit turn-on are summarized in Table 2-2 "NASA Altimeter Side B - Key Events".

Table 2-2 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)
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)

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

Day	Event
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)
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)

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

Day	Event
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
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)

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

Day	Event
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)
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)

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

Day	Event
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)
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 CAL-1 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)

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

Day	Event
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 CAL-1 Sweep Test was invalidated by an [erroneously-scheduled] ALT calibration command file.
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).**

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

Day	Event
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).
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).

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

Day	Event
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).**
Note: The key events since last update are indicated in **bold** type.	

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 is to monitor the shape of the altimeter's CAL-1 waveform, looking for changes over time. Until day 223 of 2002, CalSweeps were regularly performed every 30 days, beginning with Side A on day 251 of 1998. Beginning with day 223, CalSweeps have been performed every 10 days in an effort to better understand the recent observed irregular CAL-1 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, and throughout the year 2003, we have monitored the land-to-water acquisition times, and we continue to use the AGCMIN15 parameter file as our standard.

Global plots of acquisition anomalies are depicted by the black lines in Figure 2-18 (Cycle 358 in June 2002), Figure 2-19 (Cycle 381 in January 2003), Figure 2-20 (Cycle 391 in April-May 2003) and Figure 2-21 (Cycle 410 in November 2003). In Figure 2-18 and Figure 2-19, no particular abnormal acquisitions are noted, continuing the span of acceptable acquisition times since day 243 of 1999.

In Figure 2-20, however, for the first time since 1999, there are several slow acquisitions observed: (1) off the southern tip of Africa; (2) off the southeastern coast of South America; (3) between Australia and Tasmania; and (4) in Indonesia. In Figure 2-21, there are some slow acquisitions noted: (1) off the island of Tasmania, (2) in the Caribbean Sea; (3) off the northeastern coast of South America; (4) off New Zealand; (5) off the southern coast of Saudi Arabia; and (6) again in Indonesia.

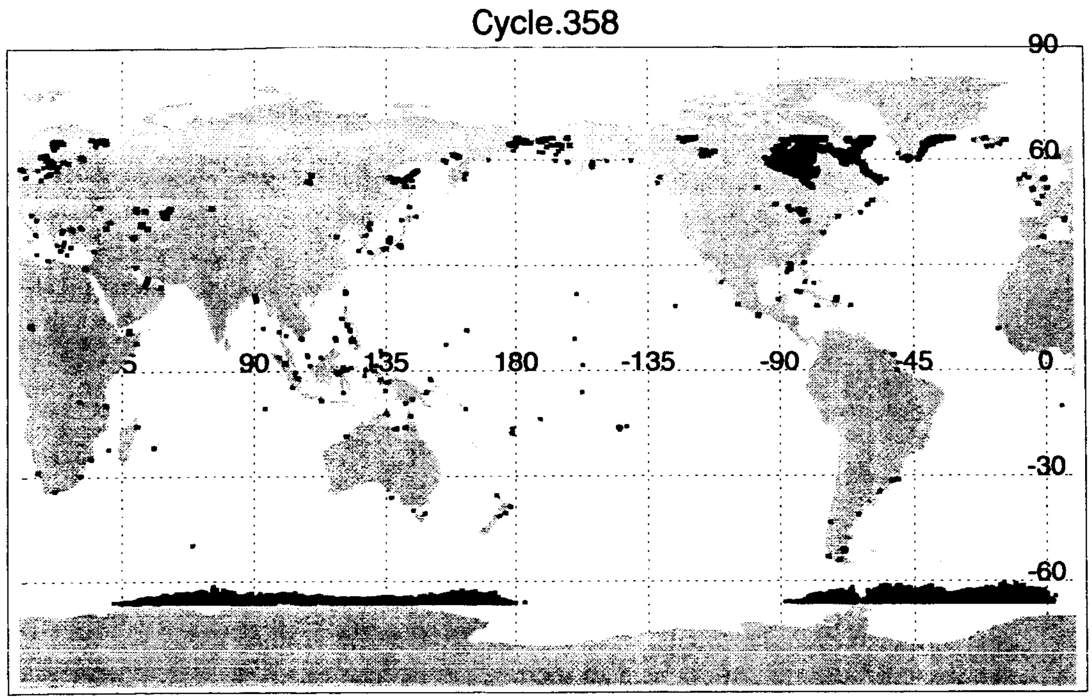


Figure 2-18 Cycle 358, with Areas of Land-to-Water Acquisition Anomalies

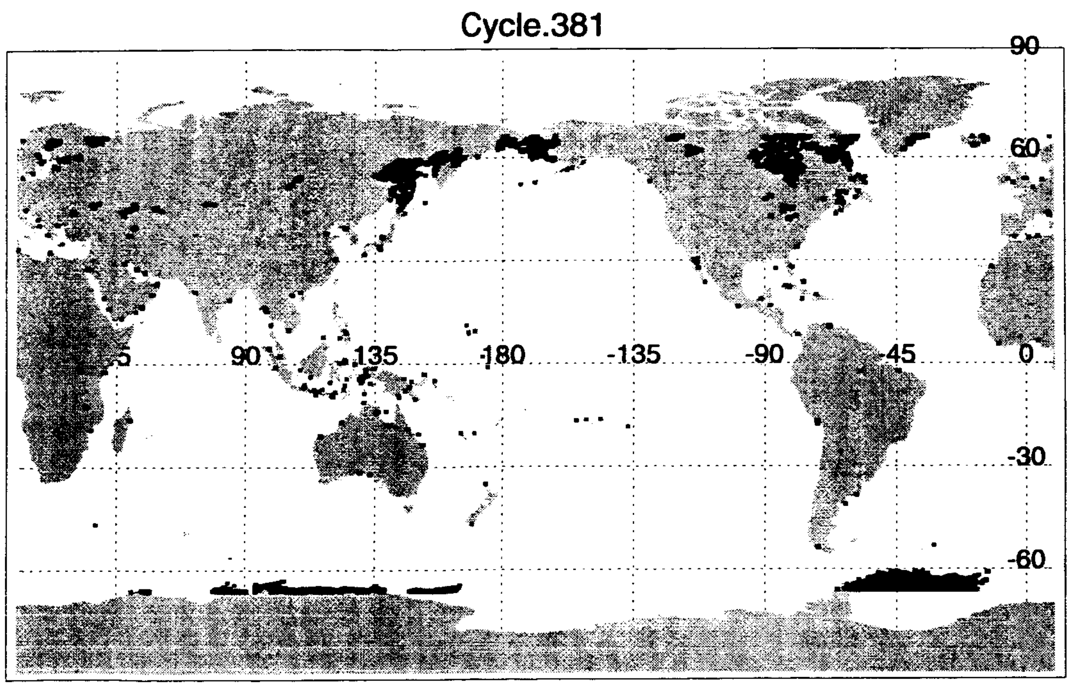


Figure 2-19 Cycle 381, with Areas of Land-to-Water Acquisition Anomalies

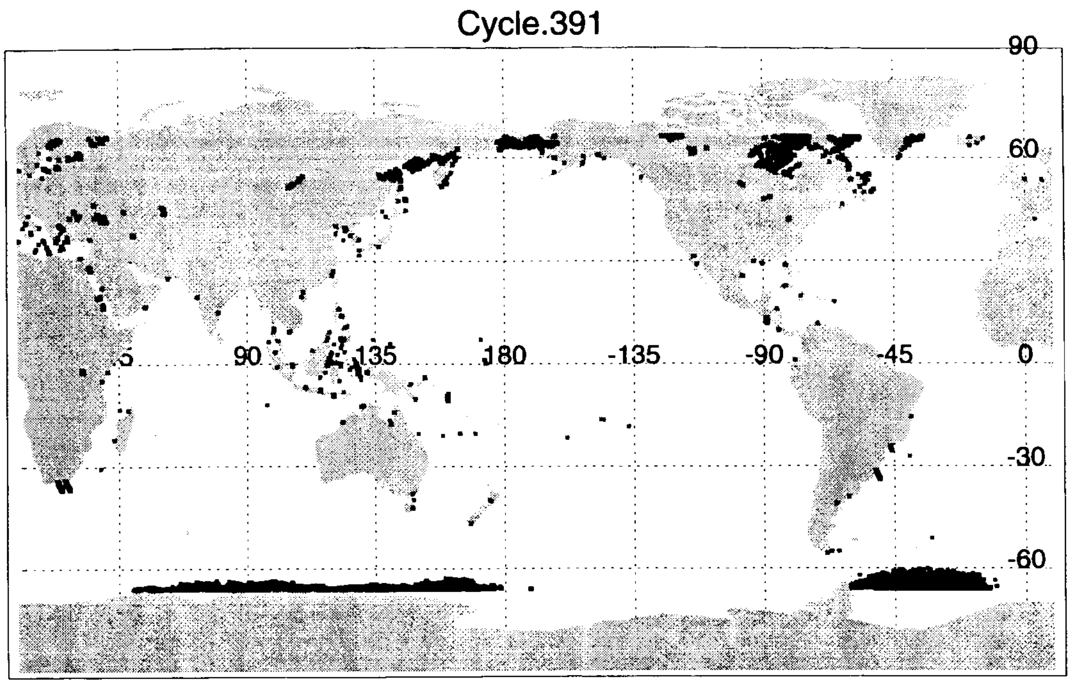


Figure 2-20 Cycle 391, with Areas of Land-to-Water Acquisition Anomalies

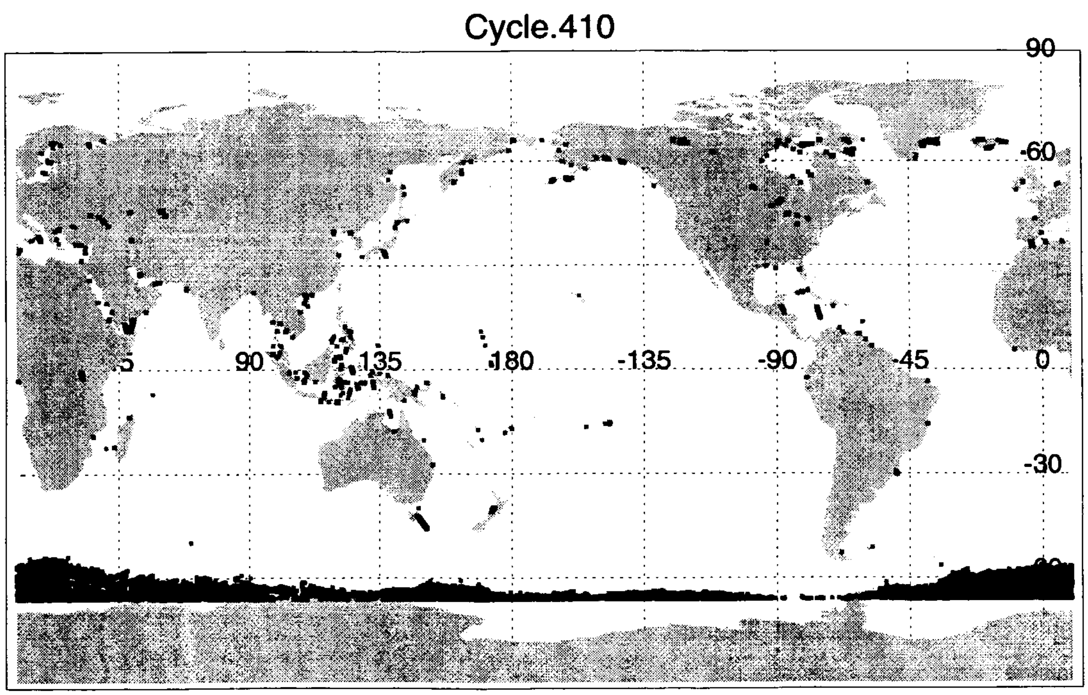


Figure 2-21 Cycle 410, with Areas of Land-to-Water Acquisition Anomalies

While there are a few slow acquisitions observed in these recent cycles, their occurrences and their 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. We will continue to monitor the acquisition times.

2.4.2 Attitude Anomaly

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 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.

During the year 2003, there was a spike on day 2003-116, in conjunction with a maneuver yaw unwind (OMM24).

Also during the year 2003, there were two instances, over a course of about nine days, that there were short-duration attitude excursions that spiked up to about 0.14 degrees. This was about 0.05 degrees above the norm. These two instances occurred subsequent to the following commands:

- Start Solar Array Ramp to Bias Position
- Stop Solar Array Ramp to Bias Position +36.0
- Start Yaw Ramp (Fixed to Sinusoidal BETAP = -30.0)
- Stop Yaw Ramp (Fixed to Sinusoidal)

The range noise, the AGC, and the SWH values appear reasonable throughout the attitude anomalies.

Section 3

Assessment of Instrument Performance (Cycles 236 through 415)

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 cycle 415 which was the last complete cycle in year 2003 (starting on 2003 day 354 and ending on day 364). 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 CAL-1 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 have been 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 are 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 CAL-1 processing scheme to remove the effects of a 7.3 mm range quantization in the TOPEX internal calibration mode. The Side B is almost identical to Side A, the same calibration mode quantization is present in the CAL-1 delta range data, and we have used the same processing method to remove these quantization effects.

In previous years we had found that the Side A delta ranges had a temperature dependence. There are about two dozen different temperatures monitored within the TOPEX altimeter, and it is not possible to determine which of these is 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.

For Side B the behavior of delta range with temperature was somewhat different. We reported last year (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. Figure 3-1 shows the full-rate Side B Tagc values through the end of cycle 415, and Figure 3-2 shows full-rate Side B C-band CAL-1 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-

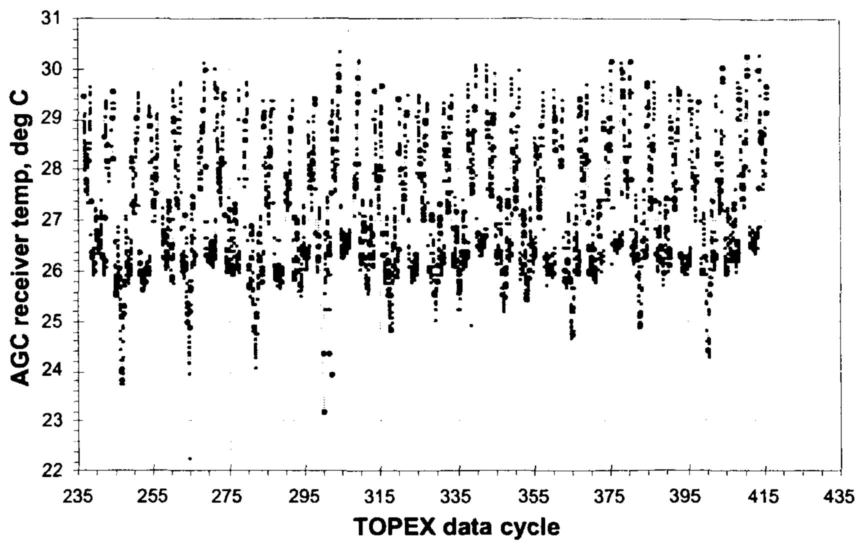


Figure 3-1 Side B AGC Receiver Section Temperature vs. Cycle

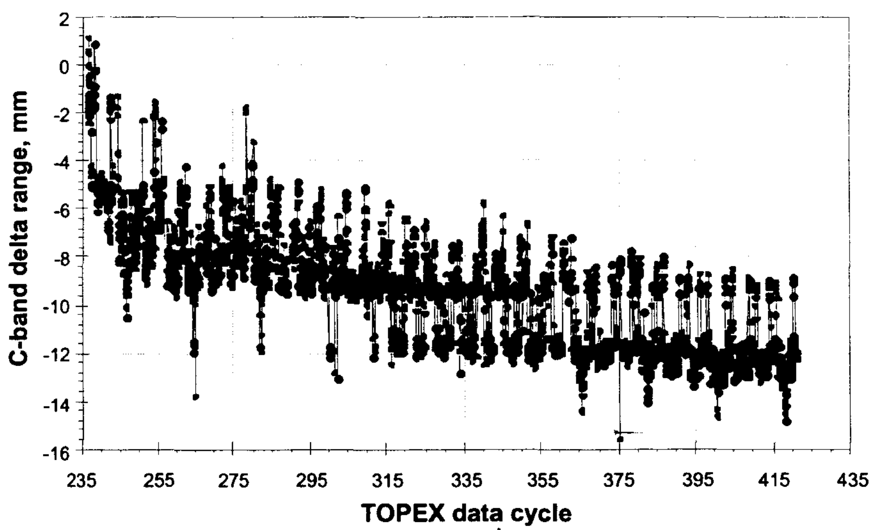


Figure 3-2 Side B Cal-1 Step-5 C-Band dRange vs. Cycle NOT Corrected for Temperature

squares fit to find the coefficients for the quadratic dependence. Figure 3-3 shows the Side B C-band delta range after making the quadratic correction for the Tagc, and it can be seen that the Tagc correction term does eliminate some of the variations of the individual data relative to the general trend.

Figure 3-4 and Figure 3-5 show the Side B Ku-band CAL-1 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

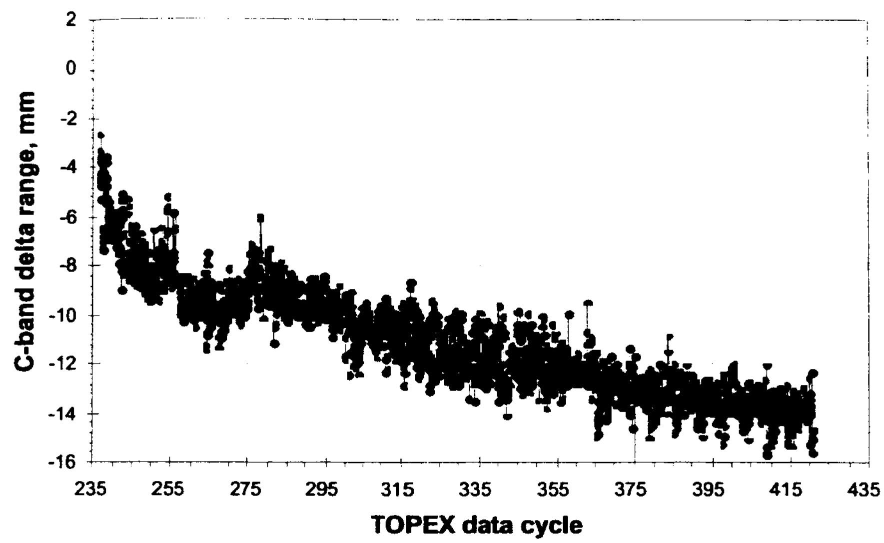


Figure 3-3 Side B Cal-1 Step-5 C-Band dRange vs. Cycle WITH Correction for Receiver AGC Temperature

noticeable feature in Figure 3-4 and Figure 3-5 is the change of character of the Ku-band CAL-1 delta range with the onset of "toggling" early in cycle 364 and continuing through the time of this report's writing. 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 toggles. Since that time we have implemented a more precise algorithm that reduces 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 are similar to that currently seen in-flight. It is now the Wallops' team feeling that in-flight, the TOPEX altimeter Side B has aged such that the MTU component now operates on the edge of this toggle zone.This type of shift in hardware characteristics is not uncommon in ground based radars. Our analysis shows no significant effect on the TOPEX range performance, and we are not concerned about any reliability issues. Nothing can be done to remove or compensate for the toggling in the Cal-1 Ku delta height if it is coming from this device. In Figure 3-3 and other figures showing CAL-1 ranges with correction for the receiver AGC temperature, the Tagc corrections are based on fits to results from cycles 236 through 363, the Side B data period before the onset of the toggling.

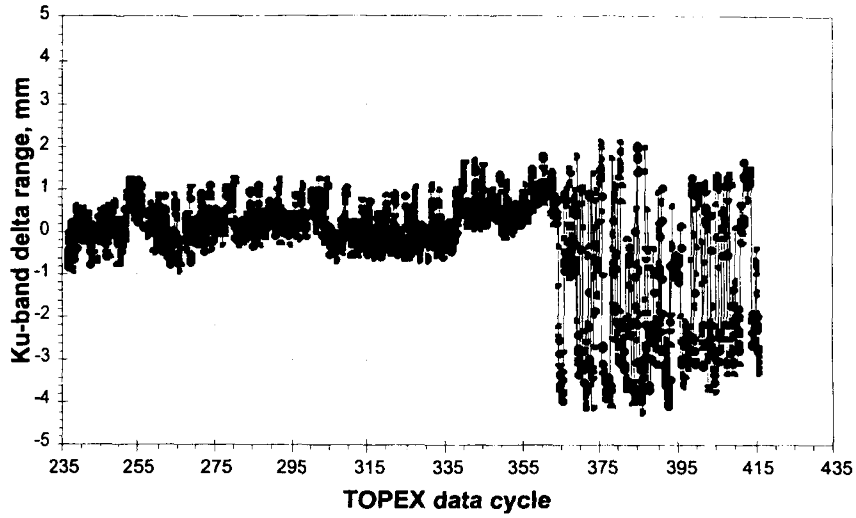


Figure 3-4 Side B Ku Cal-1 Step-5 dRange vs. Cycle with NO Temperature Correction

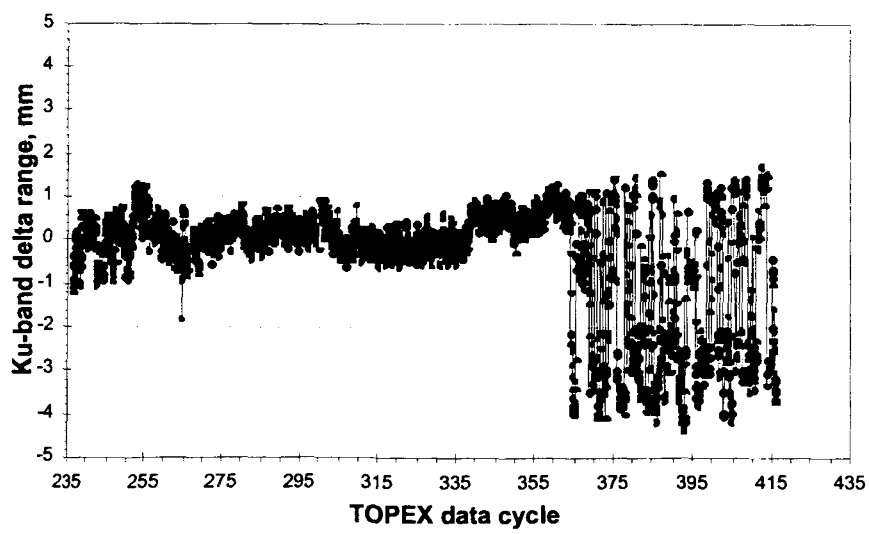


Figure 3-5 Side B Ku Cal-1 Step-5 dRange vs. Cycle after Correction for Receiver AGC Temperature

Figure 3-6 and Figure 3-7 compare the Side B combined delta range results before and after Tagc corrections, and the Tagc corrections have little discernible effect. Because the combined delta range is 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.

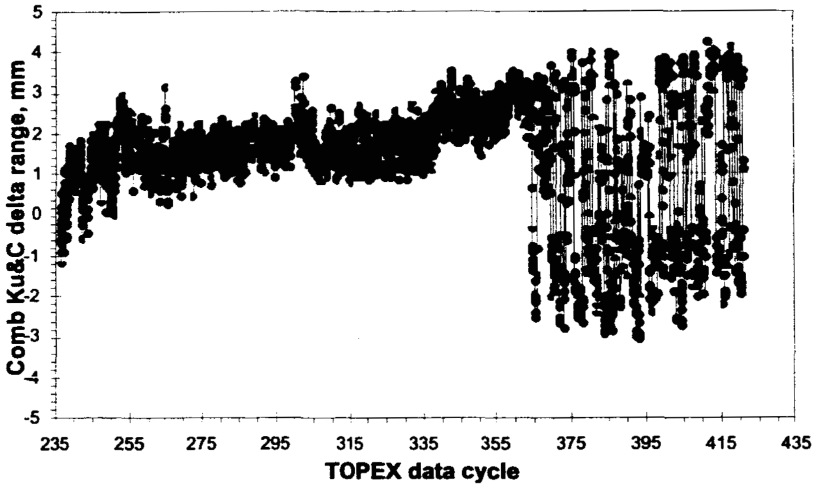


Figure 3-6 Side B Cal-1 Step-5 Comb dRange vs. Cycle with NO Temperature Correction

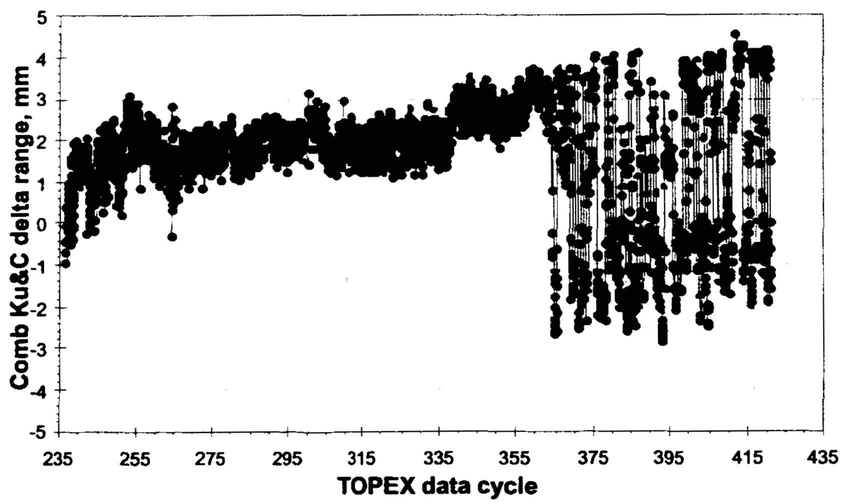


Figure 3-7 Side B Cal-1 Step-5 Comb dRange vs. Cycle after Correction for Receiver AGC Temperature

As determined previously for Side A, the Side B general trend of delta ranges is sufficiently slow that corrections can 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-

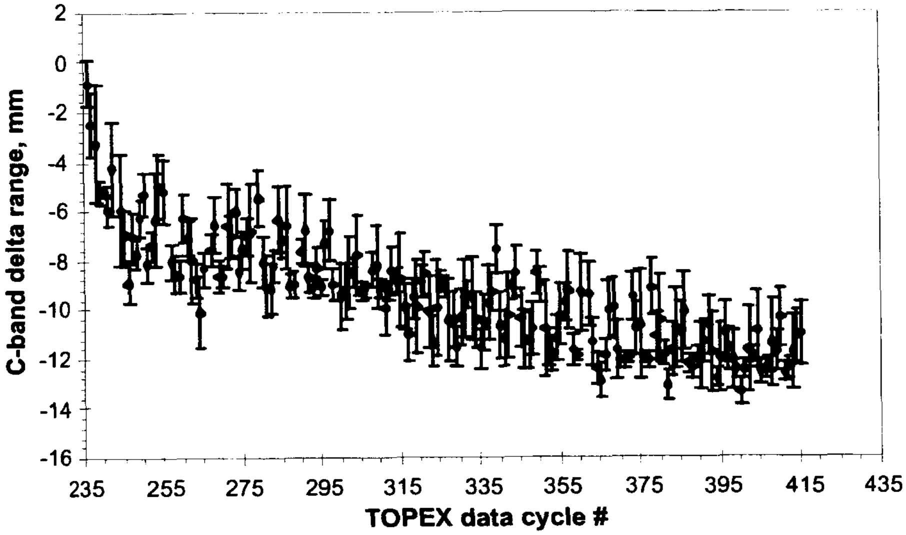


Figure 3-8 Side B C-Band Cycle Average Delta Range vs. Cycle NOT Corrected for Temperature

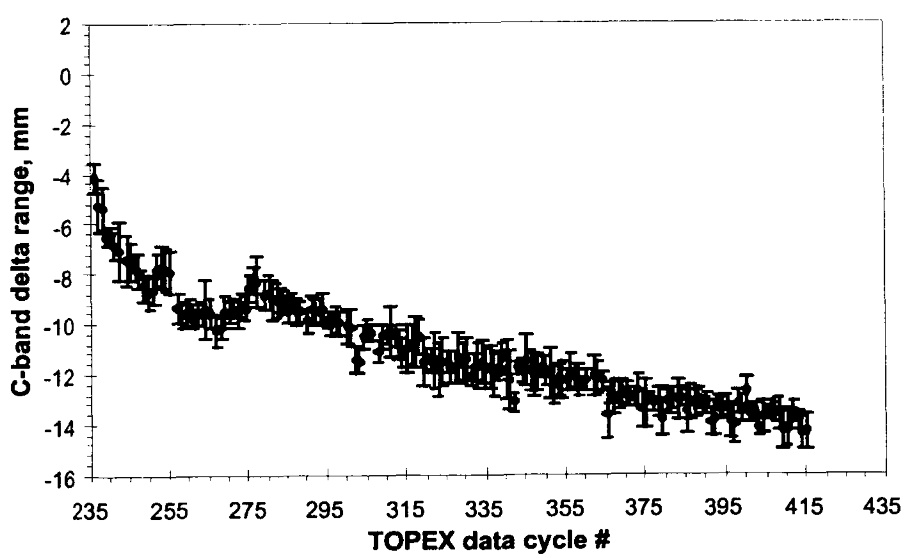


Figure 3-9 Side B C-Band Cycle Average Delta Range vs. Cycle WITH Correction for Receiver AGC Temperature

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 com-

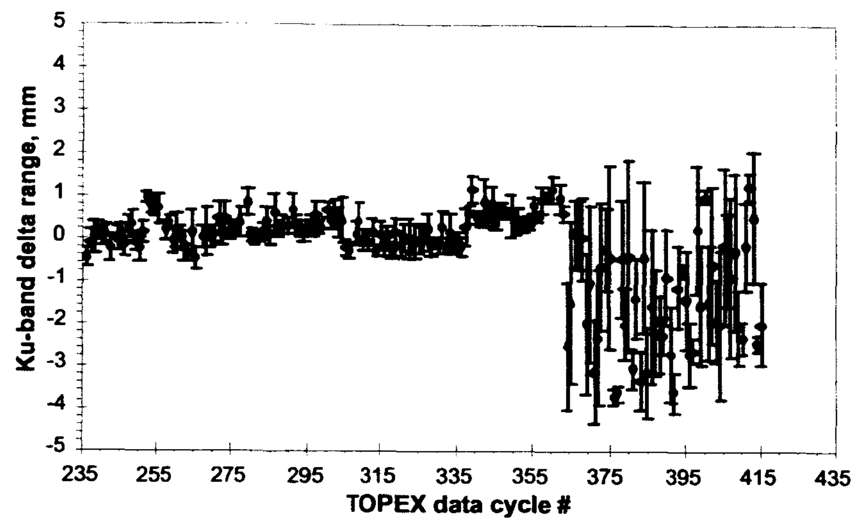


Figure 3-10 Side B Ku-Band Cycle Average Delta Range vs. Cycle NOT Corrected for Temperature

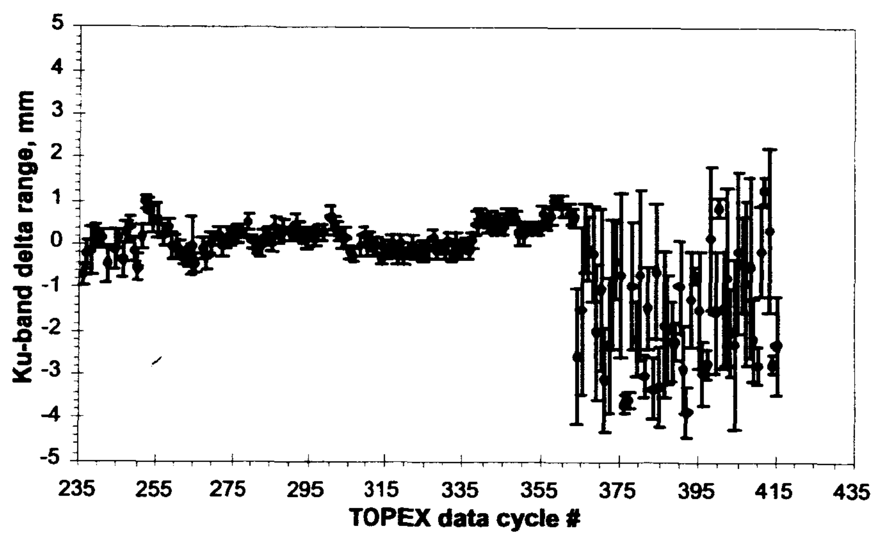


Figure 3-11 Side B Ku-Band Cycle Average Delta Range vs. Cycle WITH Correction for Receiver AGC Temperature

bined height delta ranges without and with the Tagc correction.There is little apparent benefit to using the Tagc correction for the combined delta range, and the Tagc is not available on the TOPEX GDR data product, so we strongly recommend using the Side B combined delta ranges with NO temperature correction.

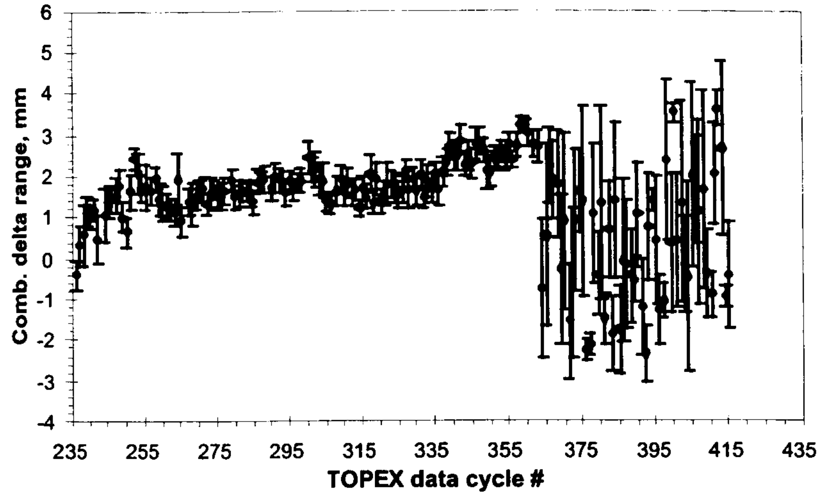


Figure 3-12 Side B Combined (Ku&C) Cycle Average Delta Range vs. Cycle NOT Corrected for Temperature

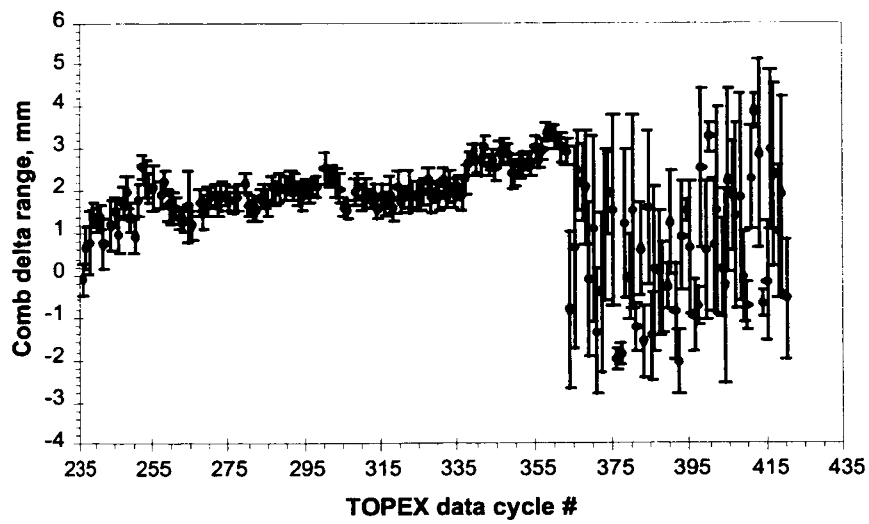


Figure 3-13 Side B Combined (Ku & C) Cycle Average Delta Range vs. Cycle WITH Correction for Receiver AGC Temperature

Figure 3-14 plots the cycle-averaged combined delta range (with no temperature correction) for all TOPEX cycles from start of mission through the end of year 2003, so that the Side A and Side B behavior can be compared. These cycle-averaged delta range values are printed in Table C-1, and are also available at our TOPEX web site

http://topex.wff.nasa.gov/docs/RangeStabUpdate.html

That web site is updated every month or so. 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 is to use the delta range that has NO temperature correction.

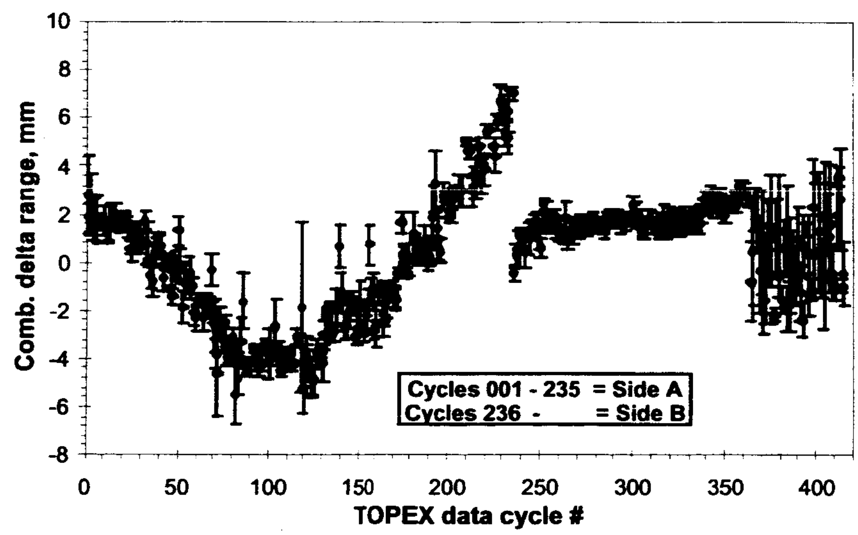


Figure 3-14 Combined (Ku & C) Cycle Average Delta Range vs. Cycle NOT Corrected for Temperature

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 C-1 in Appendix C (as plotted in Figure 3-9). Note that the delta ranges are all given relative to a constant but arbitrary range offset, so this correction will provide 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 CAL-1 delta range toggling described earlier in this report section, we do not know the reason for this change in TOPEX Side B Ku-band

CAL-1 delta range behavior which became apparent early in cycle 364 and has continued for all subsequent cycles. We have been unable to correlate this Ku-band CAL-1 range toggling with any of the temperatures, voltages, and powers available in the TOPEX engineering telemetry. There is a hint of a relationship between the changes in Ku-band CAL-1 delta range and the Tagc as shown in Figure 3-15 which plots the

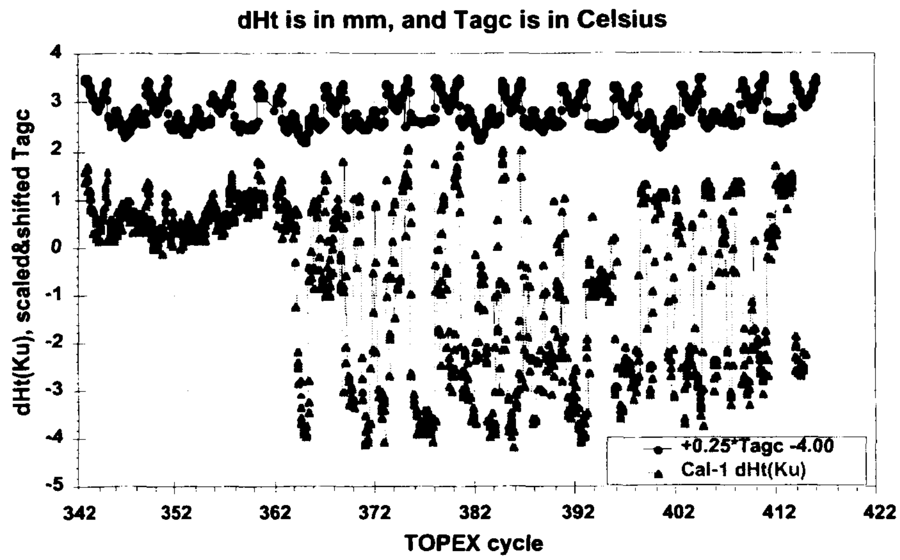


Figure 3-15 TOPEX Cal-1 Data from Start of Year 2002

CAL-1 Ku delta range and a shifted and scaled Tagc vs. data cycle. Notice the relationship between Ku CAL-1 range and the Tagc around cycles 364, 376, 394, and 413. The vertical transitions in these quantities are more or less correlated in time (or data cycle), but the direction of the change is not; around cycle 376 the Tagc and the Ku CAL-1 range both move downward, but around cycle 394 these two quantities move in opposite directions.

We have calculated the correlation between Ku delta range and Tagc for TOPEX Side B before and after the onset of the toggling in the Ku delta range. A width of 81 data points was used in the correlation calculations, and Figure 3-16 shows the centered 81-point correlation values plotted vs. data cycle. Since the Cal-1 mode is executed about 20 times per cycle, the 81-point correlation has an equivalent total width of about four cycles or about +/- two cycles. Figure 3-16 indicates that the Tagc:dH(Ku) correlation values do not change appreciably at cycle 364, the cycle of onset of the toggling behavior. The correlation values are positive and generally between 0.2 and 0.8 for cycles up to about cycle 380. By cycle 395, however, the correlation has become negative with values generally between -0.65 and -0.85. The 81-point computation width was arbitrarily chosen, and the appearance of Figure 3-16 might be expected to change if the number of points used in the correlation calculation is changed. We have varied the computation width and found that the correlation curve becomes somewhat smoother as the computation width is increased, but that the general trend remains the same as Figure 3-16. This is consistent with the suspicion that the toggling is coming from the MTU component that has toggling within a specific temperature range as described in a preceding paragraph. Our conclusion is that there is no conceivable way to use Tagc to build any sort of correction procedure to compensate for the delta Ku range toggling.

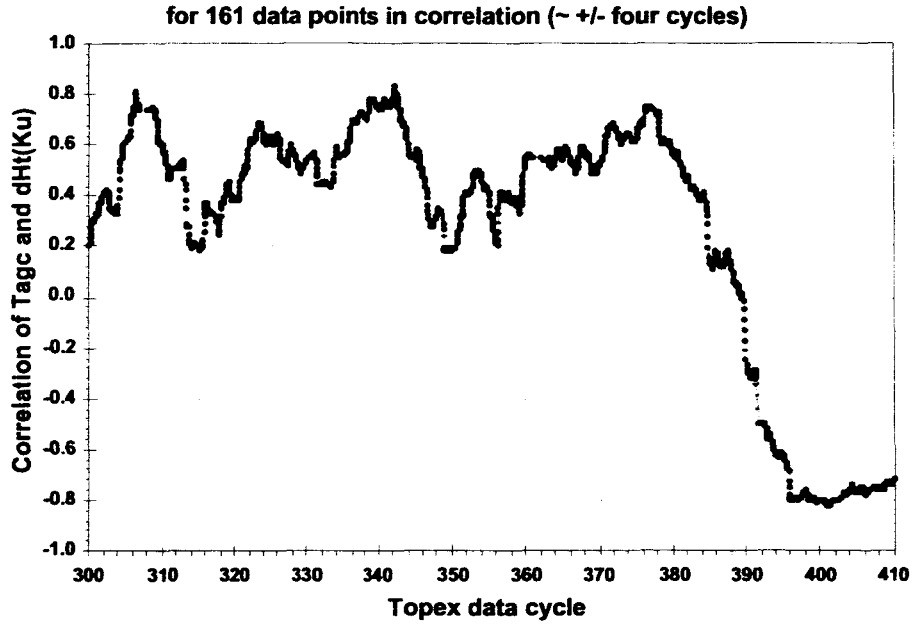


Figure 3-16 TOPEX Tagc:dH(Ku) Correlation vs. Cycle

3.2 AGC/Sigma0

The ocean surface's radar backscattering cross section, one of the quantities estimated by the TOPEX radar altimeter, is designated by σ^0 which for typographical convenience is often referred to 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 includes 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 had expected that the Cal Table would be based on AGC data in the internal CAL-1 mode (see Section 2.1). However, in Side A it became apparent that the sigma0 trends deviated somewhat from the CAL-1 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 cycle 415, the last complete cycle in year 2003. Our sigma0 trend analyses use the sigma0 before the Cal Table corrections have been 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 continuing TOPEX support, we do daily quick-look processing of all TOPEX altimeter data for performance monitoring, providing performance summaries for the engineering and science data. The daily processing results are used to update a launch-to-date engineering database. Also, data are processed from the twice-daily execution of the altimeter's internal calibration mode (with submodes CAL-1 and CAL-2) and these results are used to update a WFF launch-to-date calibration database. We also process the intermediate geophysical data record (IGDR) data as they become available for network access, normally several days after the altimeter acquires the data. The IGDR data are processed for altimeter performance, and 1-minute summary records are produced and are added to a WFF launch-to-date GDR database. When the final GDR data become available, they replace the IGDR data already in our database. There is no difference however between sigma0 data on the IGDR and the GDR, because no further sigma0 corrections are made in going from the IGDR to the GDR.

We have been very concerned about possible contamination of the data by what we have 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 show the same behavior in a bloom region. Such blooms in the TOPEX data can persist for several tens of seconds, and the waveforms in a bloom region generally have too rapid a plateau decay. Many of these waveforms are too sharply peaked ("specular"), indicating a breakdown in the general incoherent scattering theory used to characterize the rough surface scattering. The sigma0 blooms exist in perhaps 5% of all TOPEX over-ocean data (there is additional sigma0 bloom information at http://topex.wff.nasa.gov/blooms/blooms.html). As input constraints to our GDR database 1-minute averages, we require all the available altimeter flags to show normal tracking and the land/water flag to show deep water. When the data are extracted from this database for the sigma0 calibration, all records are 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 delete most of the sigma0 blooms.

Because our analysis is based on sigma0_uncorr, we need to know what Cal Table values have been already applied to the GDR (or IGDR) data in order to "undo" these corrections. Last year's report, *TOPEX Radar Altimeter Engineering Assessment Report Update - Side B Turn-On to January 1, 2003,* Vol. 17, NASA/TM-2004-212236, provided a history of the Side B sigma0-related Cal changes. TOPEX has been operating very stably for all of year 2003 with no significant drifts evident in the Ku- and the C-band Cal Table corrections, and no sigma0-related Cal Table updates have been 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.

3.2.2 Latest Fitted Sigma0 Trends for Estimation of Cal Table Values

Figure 3-17 shows the TOPEX Side B Ku-band CAL-1 and CAL-2 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 CAL-2 delta AGC and the transmitter power monitor values have been shifted to use a common vertical plot axis.

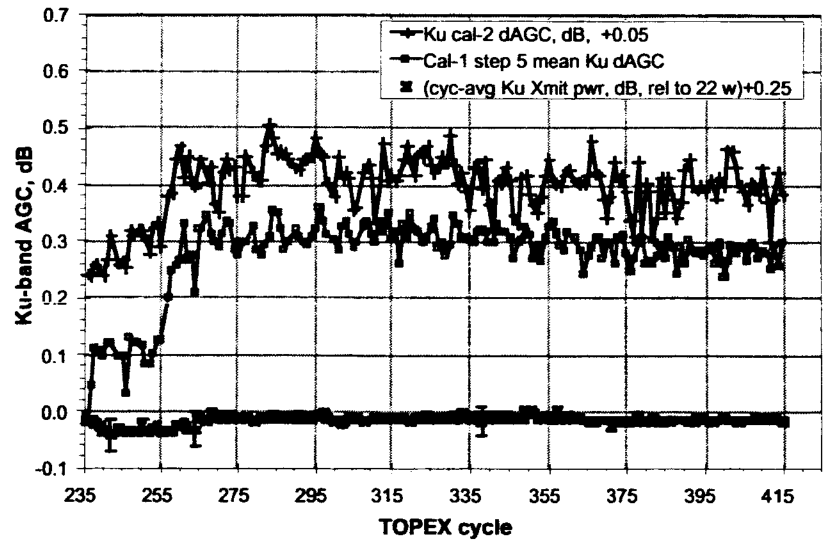


Figure 3-17 Ku Side B Cycle-Averaged Cal-1 & Cal-2 Delta AGC (Cal Table Corrections Removed)

Figure 3-18 shows the corresponding data for the TOPEX Side B C-band altimeter. The Ku-band Figure 3-17 suggests a step change in both the CAL-1 and CAL-2 delta AGC data following the TOPEX safe hold which occurred during cycle 256, while the transmitter power monitor shows almost constant data from the start of Side B operation (beginning with cycle 236) through the end of cycle 415 (the last complete cycle in year 2003). The C-band, Figure 3-18, however, show no step in the delta AGC data, but does indicate a general downward trend in the transmitter power monitor data. Next, Figure 3-19 plots the Side B Ku-band cycle averages of CAL-1 delta AGC and of over-ocean sigma0 vs. cycle. Notice that both curves show a similar step change at cycle 256. Figure 3-20 plots the corresponding C-band data, and does not show a step change at cycle 256 but does show a divergence of the two curves at higher cycle number. For the sigma0 data in Figures Figure 3-19 and Figure 3-20 and for the following sigma0 trend fits in this section, we have first applied to the uncorrected sigma0 an empirical seasonal correction which is based on the Side A data from cycles 17 through 235.

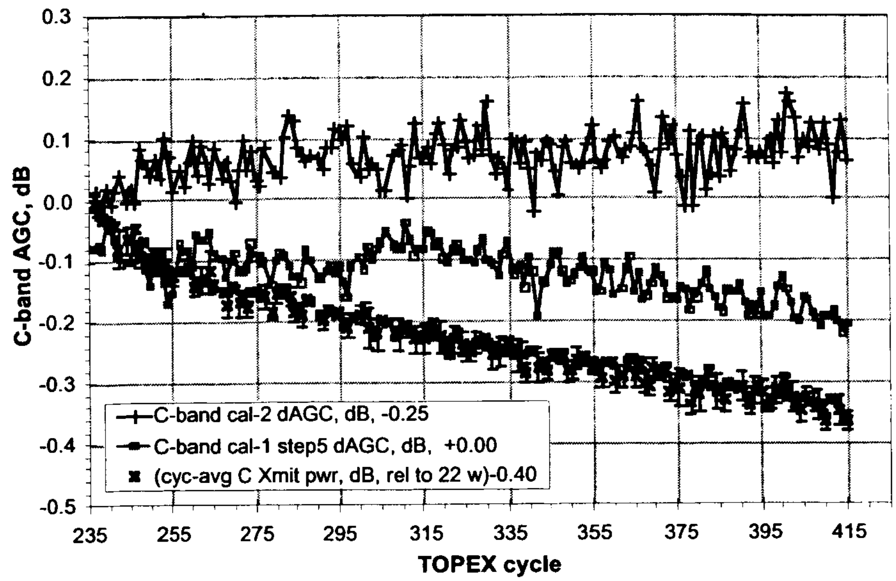


Figure 3-18 C-Band Side B Cycle-Averaged Cal-1 & Cal-2 Delta AGC (Cal Table Corrections Removed)

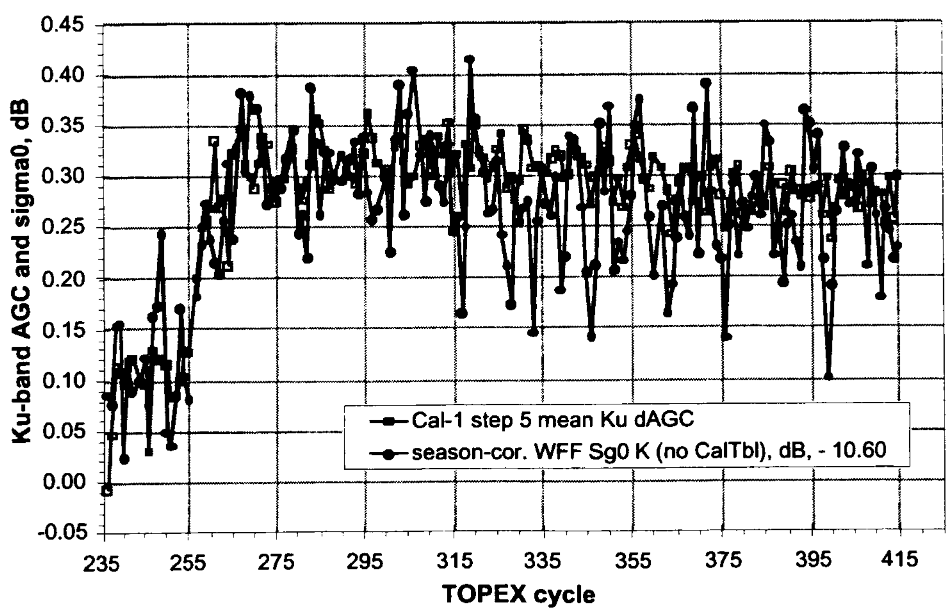


Figure 3-19 Ku Side B Cycle-Average Cal-1 Delta AGC and Sigma0 (Cal Table Corrections Removed)

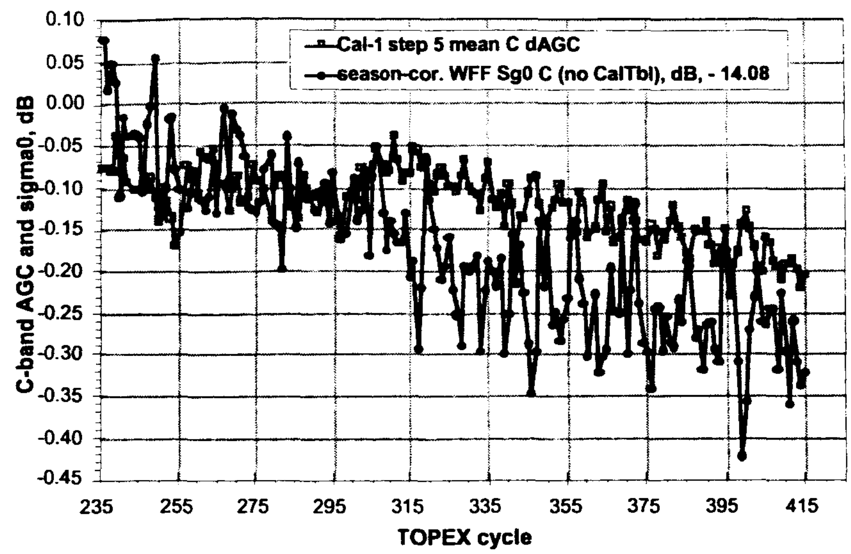


Figure 3-20 C-Band Side B Cycle-Average Cal-1 Delta AGC and Sigma0 (Cal Table Corrections Removed)

Figure 3-21 plots the differences of the Ku-band data of Figure 3-19 and of the C-band data of Figure 3-20. Figure 3-21 also plots the results of a low order polynomial fit to the difference data. Interestingly, the Ku-band step change at cycle 256 disappears in this Ku-band difference plot, while the C-band difference plot shows a decay with increasing cycle number which is 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 3-21 trends from the CAL-1 delta AGC data and then use these detrended CAL-1 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 was beginning 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 $y = (a_0 + a_1*x + a_2*x^2)/(1 + b_1*x)$, where a_0, a_1, a_2, and b_1 are fit coefficients and x is data cycle number. The a_0 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.

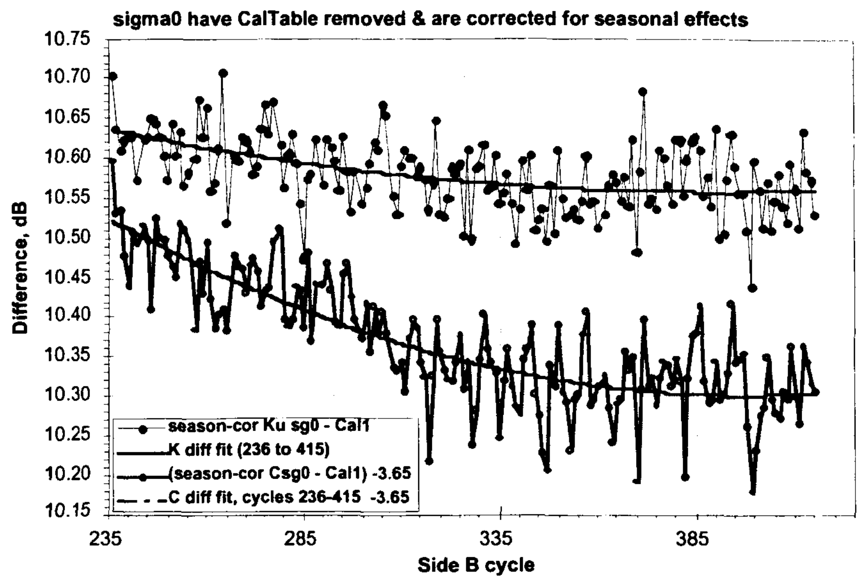


Figure 3-21 TOPEX Side B Diff's, Sigma0 minus Cal-1 Delta AGC

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 3-22.

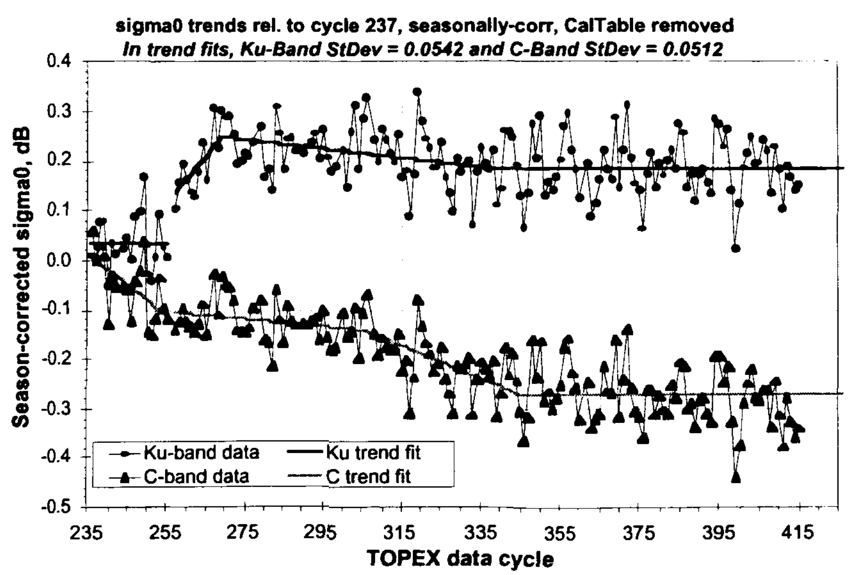


Figure 3-22 TOPEX Side B Sigma0 Trends

The (negatives of) the Figure 3-22 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 D-1. These are our best current guess at 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 D-1).

The sixth and seventh columns in Table D-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 values are plotted for Ku-band in Figure 3-23 and for C-band in Figure 3-24. Figure 3-25 shows

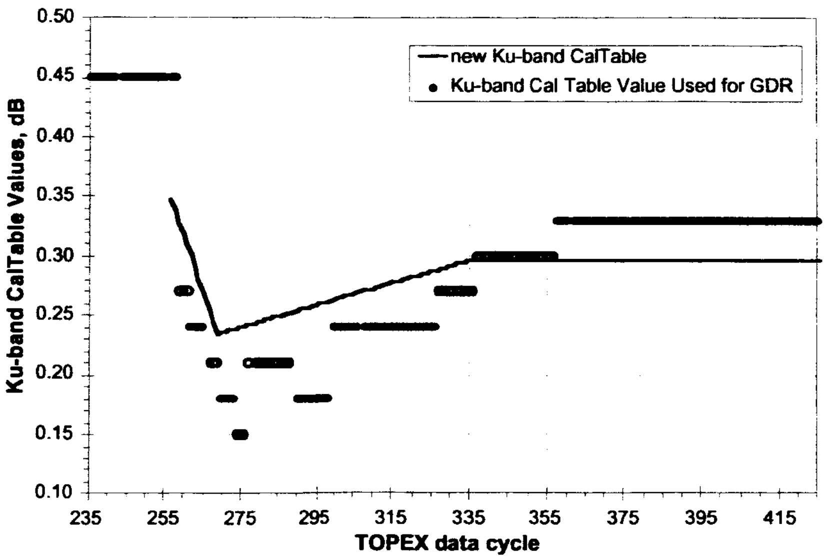


Figure 3-23 Side B Ku-Band Old and New Cal Table Values vs. Data Cycle

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 D-1 data, as plotted in Figure 3-23 through Figure 3-25, represents our current best guess at the Cal Table corrections, but this guess may change slightly as more TOPEX data are acquired and the trends are reevaluated. We continually monitor the altimeter's power-related trends, and we document these trends at the web site http://topex.wff.nasa.gov/docs/docs.html.

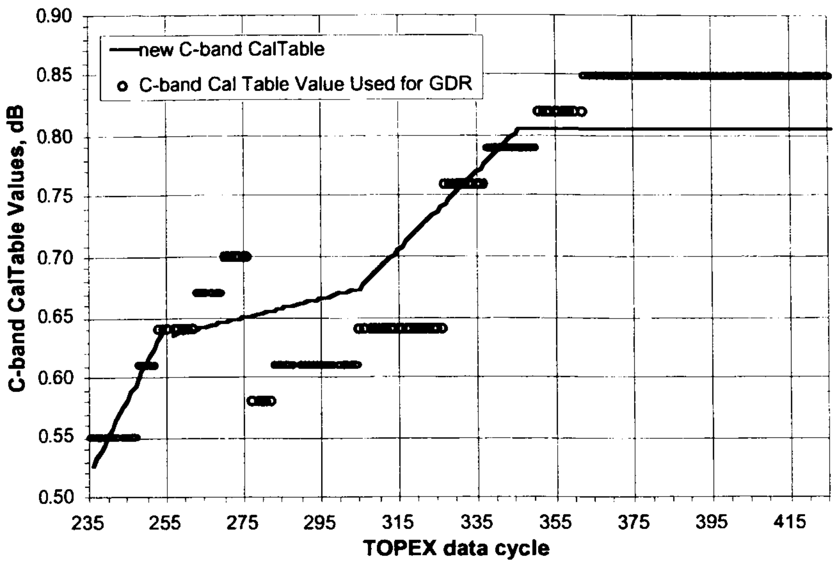


Figure 3-24 Side B C-Band Old and New Cal Table Values vs. Data Cycle

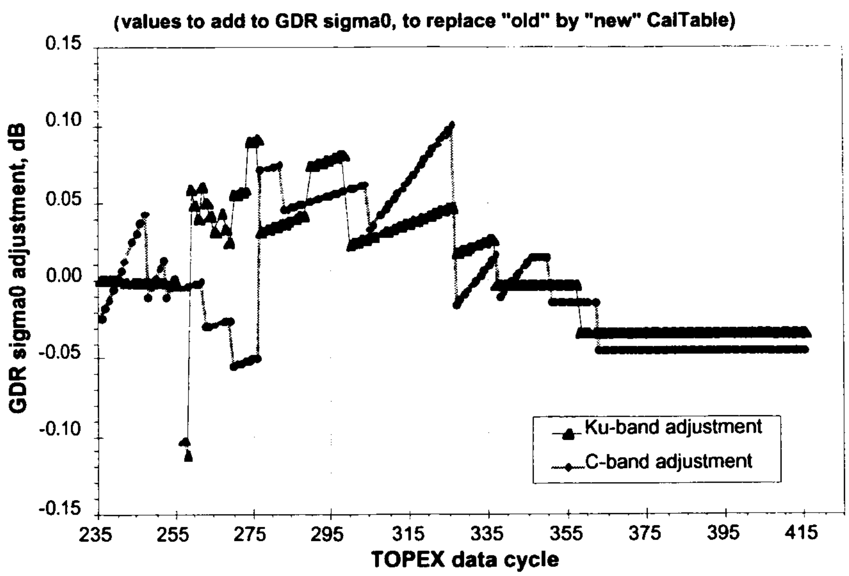


Figure 3-25 TOPEX Side B Sigma0 Adjustments vs. Cycle

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 (CAL-1). 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.

The normal TOPEX CAL-1 has been executed at least twice daily throughout the entire TOPEX operation. In CAL-1 a portion of the transmitted signal is fed back into the altimeter receiver through a special calibration attenuator and the altimeter tracks this transmitted signal using a special tracking algorithm. During the preflight testing a special calibration mode sweep test (the CalSweep) had been 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 can 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 year 1998 Engineering Assessment Update (published in August 1999) contains a more detailed discussion of the Side A PTR observation by CAL-1 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 Cal-1 delta range toggling appeared early in cycle 364. From that time onward, the CalSweep has been 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 Cal-1 delta range toggling. Although we have found nothing in the CalSweep results that can be associated with the change in the Cal-1 delta ranges, the CalSweeps continue to be executed once per cycle.

Figure 3-26 shows the comparison of an early Side B Ku-band CalSweep (1999 day 042) with the last Ku-band CalSweep of year 2003 (2003 day 364). Figure 3-27 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 sinc^2 function plotted in Figure 3-26 and Figure 3-27. 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 year 2003. If there have been any changes at all in the Side B CalSweeps, these changes have been less than the size of the plot symbols in Figure 3-26 and Figure 3-27.

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 CAL-1 waveform provides only a single sample at about the peak of each of the PTR sidelobes. We maintain a database of waveforms from the first two CAL-1 modes in

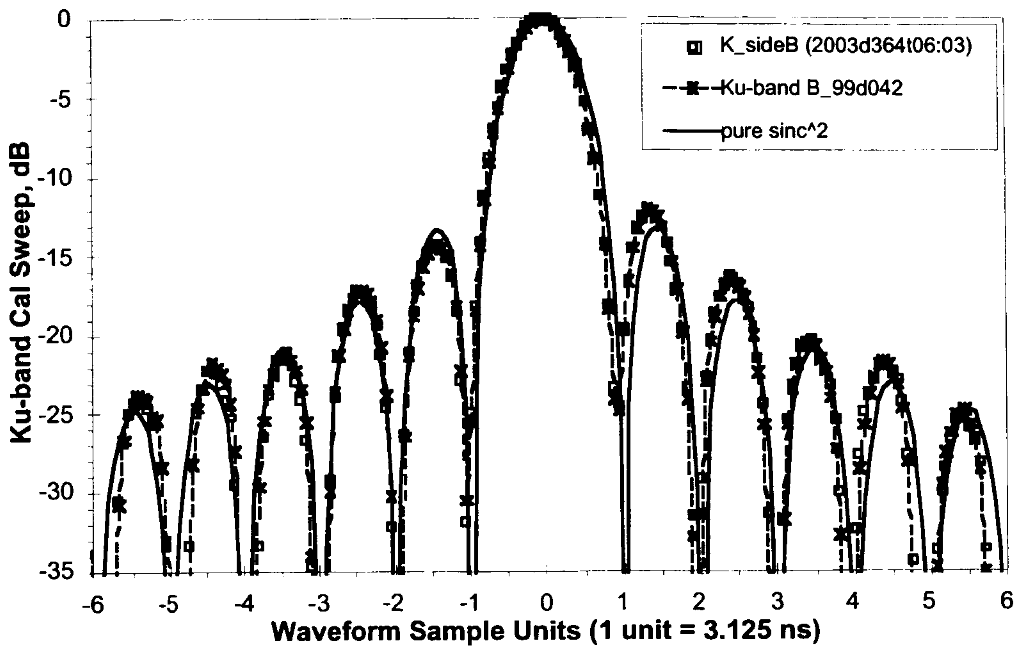


Figure 3-26 TOPEX Side B Ku-Band Cal Sweep 2003 Day 364

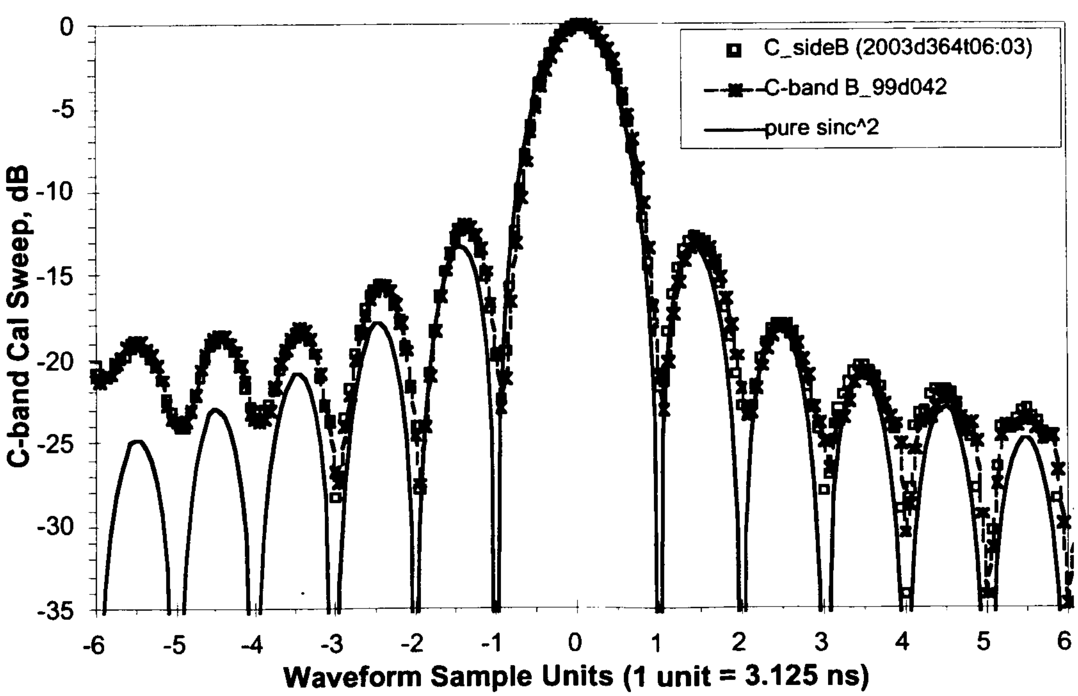


Figure 3-27 TOPEX Side B C-Band Cal Sweep 2003 Day 364

each repeat cycle, and this provides another way of assessing possible PTR changes as a function of cycle. We will use the CAL-1 step 5 waveforms for the following discussion 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 3-28 shows the time history of the first

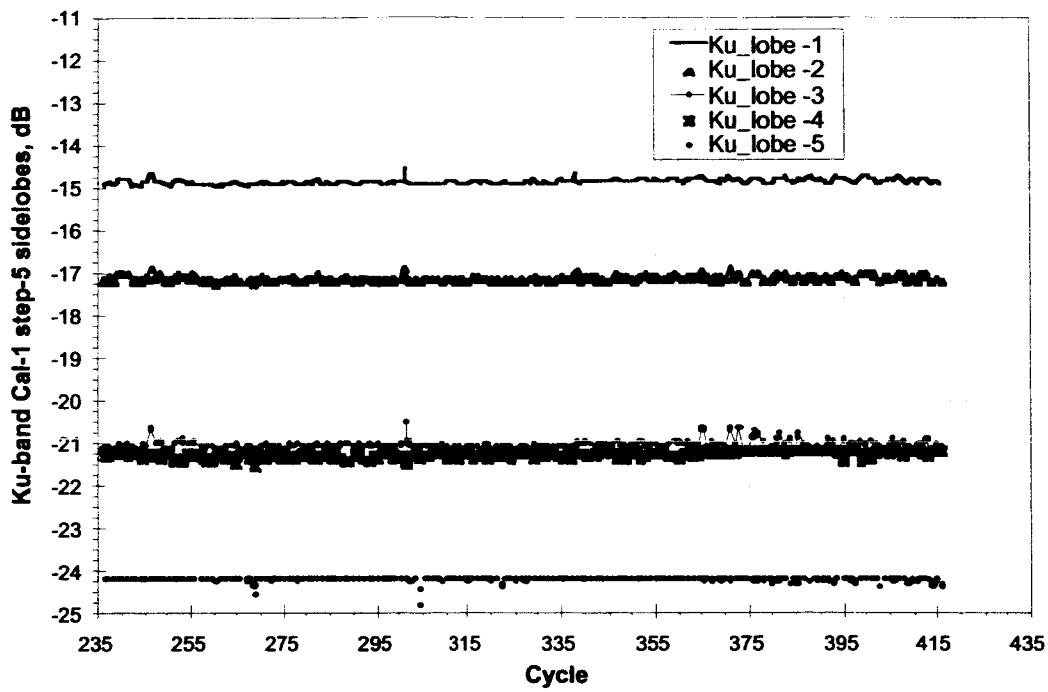


Figure 3-28 Side B Ku-band Cal-1 Lower Sidelobes Relative to Peak Value

five PTR lobes below the main peak and Figure 3-29 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 end of cycle 415 (the last cycle starting in year 2003), and none of the sidelobe peak values exhibit any significant time trend. For the Side B C-band system, Figure 3-30 shows the first five PTR lobes below the main peak and Figure 3-31 shows the first five sidelobes above the main peak. While the lower five C-band Side B PTR sidelobes in Figure 3-30 show no significant time trends, there are possible small trends in a couple of the upper five C-band sidelobes in Figure 3-31. The +2 sidelobe shows an increase of about a half dB from start of Side B through the end of cycle 379, and the +3 sidelobe shows about an increase for about 3/4 dB over this time. Figure 3-31 may possibly show a step change in these sidelobes at the cycle 256 safehold about 208 days after the start of Side B operation. We think that these changes are too small to have any practical consequences in the TOPEX range or SWH estimation, but future CalSweep and CAL-1 waveform trend results will be closely watched for possible further changes.

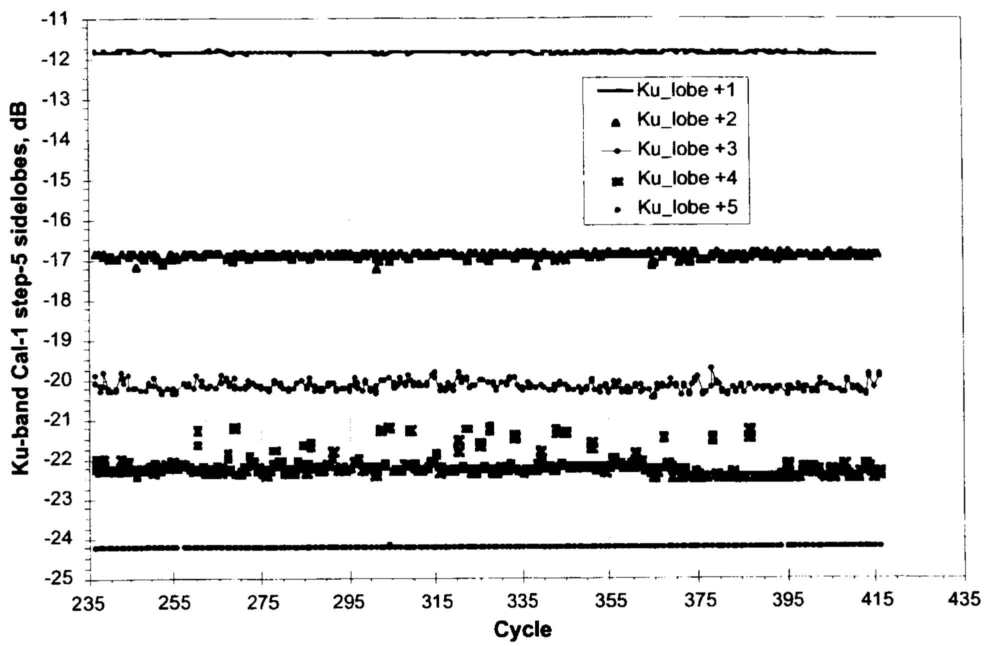


Figure 3-29 Side B Ku-band Cal-1 Higher Sidelobes Relative to Peak Value

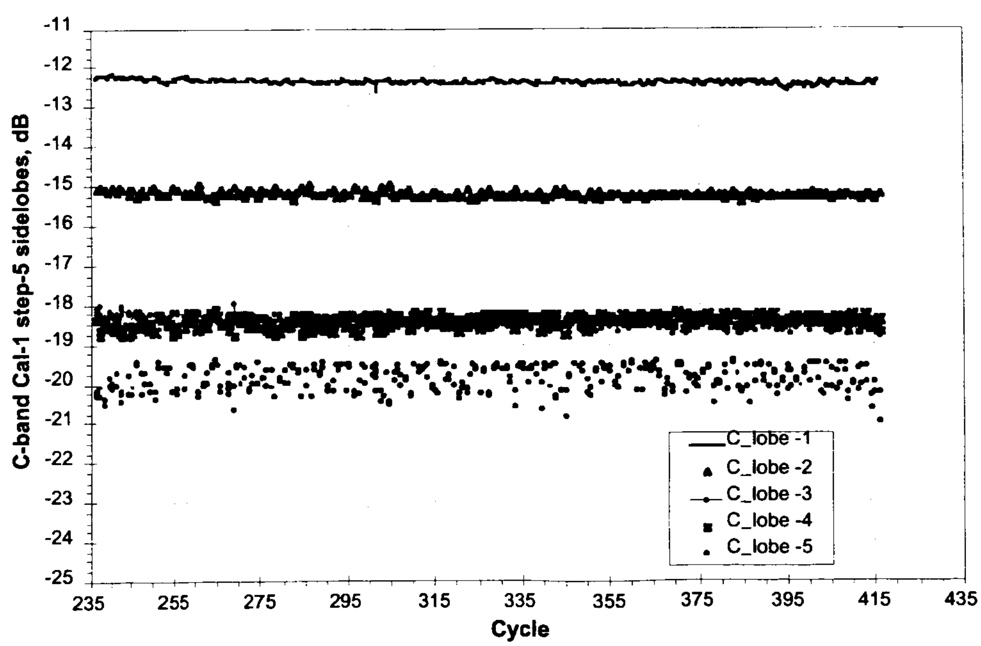


Figure 3-30 Side B C-band Cal-1 Lower Sidelobes Relative to Peak Value

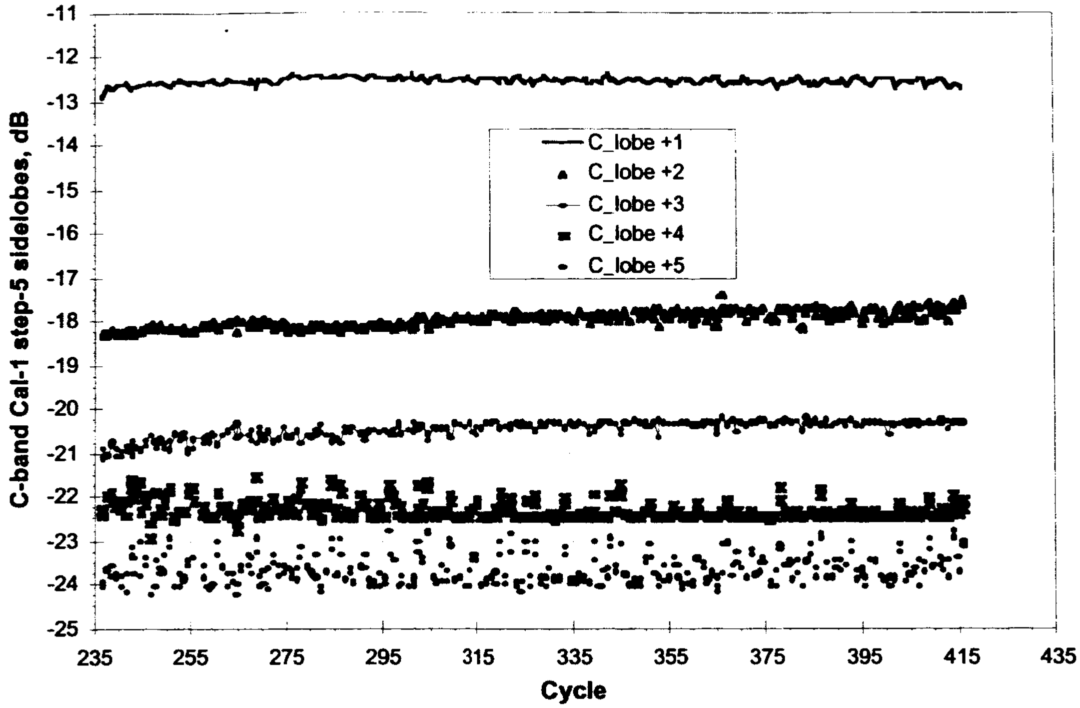


Figure 3-31 Side B C-band Cal-1 Higher Sidelobes Relative to Peak Value

Section 4

Ancillary Performance Assessments

4.1 Range Measurement Noise

The TOPEX altimeter white noise levels have been 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 isolates the portion of the spectrum that should be dominated by the white noise floor and interpreted as the contribution of the instrument noise. It is simpler to use than repeat track-sampling comparisons, allows the analysis of much larger amounts of data, and in this manner, is more efficient in estimating the noise. This monitoring of the noise level of the altimeter over time should help to detect hardware changes.

The TOPEX altimeter noise level is estimated to be about 1.8 cm for a 2 m SWH, as shown in Figure 4-1 "Plot of Selected Statistical Indicators from Table 4-1", derived from solving the fitted equation. Figure 4-1 is a good indicator of the consistent and excellent performance of Side B. The noise level estimates provided in Table 4-1 on page 4-2 demonstrate stability from cycle-to-cycle with the basic linear dependence of the noise level upon significant waveheight (SWH).

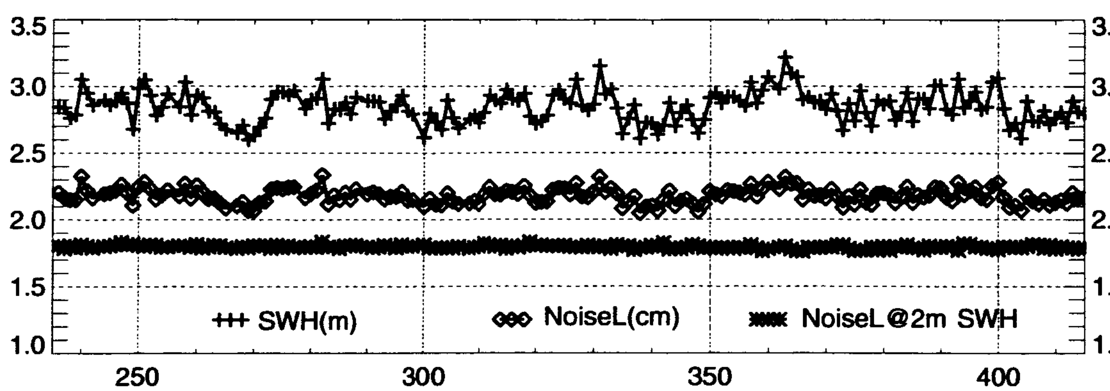


Figure 4-1 Plot of Selected Statistical Indicators from Table 4-1

Note: Cycles 243, 256, 266, 278, 289, 299, 307, and 361 are omitted in Table 4-1 because they occurred during CNES SSALT operations.

Table 4-1 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 4-1 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
1999	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

Table 4-1 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	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
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

Table 4-1 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	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
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

Table 4-1 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	345	2.802	1.158	2.14	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	2.75	1.137	2.115	0.714	1.785
2002	350	2.915	1.122	2.213	0.738	1.79
2002	351	2.951	1.189	2.19	0.712	1.783
2002	352	2.873	1.247	2.174	0.749	1.791
2002	353	2.925	1.262	2.221	0.79	1.791
2002	354	2.921	1.334	2.214	0.826	1.781
2002	355	2.89	1.263	2.204	0.797	1.791
2002	356	2.854	1.3	2.187	0.803	1.788
2002	357	3.031	1.374	2.27	0.818	1.811
2002	358	2.875	1.28	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	1.45	2.268	0.839	1.777
2002	365	3.073	1.422	2.273	0.871	1.764
2002	366	2.9	1.308	2.149	0.764	1.761
2002	367	2.92	1.393	2.227	0.844	1.793
2002	368	2.879	1.42	2.177	0.814	1.786
2002	369	2.891	1.246	2.184	0.755	1.787
2002	370	2.83	1.222	2.158	0.731	1.796
2002	371	2.944	1.289	2.23	0.801	1.79

Table 4-1 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	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	2.74	1.104	2.112	0.722	1.767
2002	376	2.968	1.26	2.227	0.795	1.769
2002	377	2.802	1.056	2.129	0.686	1.771
2002	378	2.702	1.022	2.11	0.663	1.793
2002	379	2.893	2.893	2.195	0.806	1.769
2003	**380**	**2.864**	**2.864**	**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**
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**

Table 4-1 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	**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**	**0.741**
2003	**411**	**2.808**	**1.041**	**2.148**	**0.663**	**1.799**
2003	**412**	**2.729**	**1.179**	**2.123**	**0.734**	**1.792**
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**
	Note: The statistical indicators since last update are indicated by **bold** type.					

4.2 Differencing as a Continuing System Health Monitor

An ancillary method of performance analysis we use is the differencing of parameters. The method has proven 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 year 2003. The entire range of the delta SWHs is very small, only about 0.01 meters, and we expect to use the delta SWH cycle-averages as a continuing system health monitor rather than as a product having any particular science usefulness.

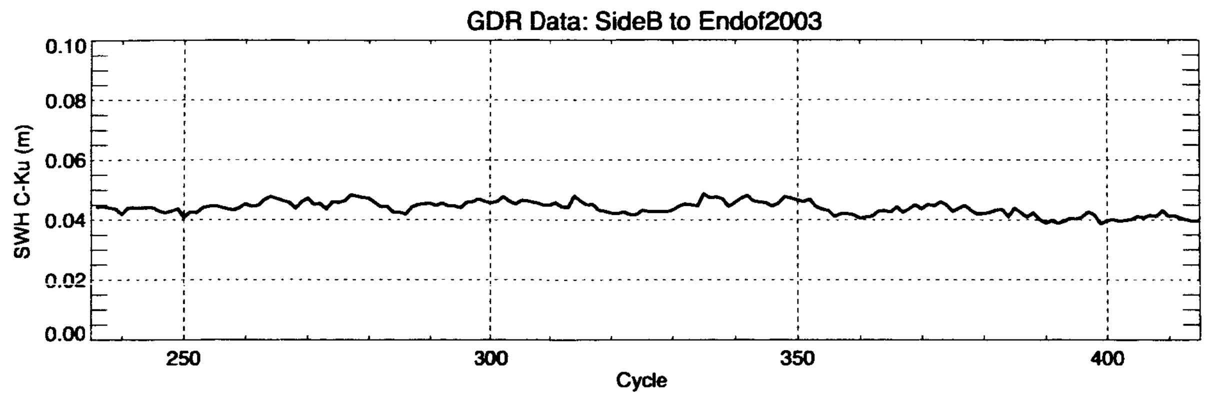


Figure 4-2 Cycle-Average SWH Delta in Meters

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 year 2003. The secondary gate is designated in the plot as SC, and the primary gate is PR. We see a small and sufficiently steady difference between the gate selection for each of the two frequencies. This figure is again a system health monitor that illustrates the excellent performance stability of Side B.

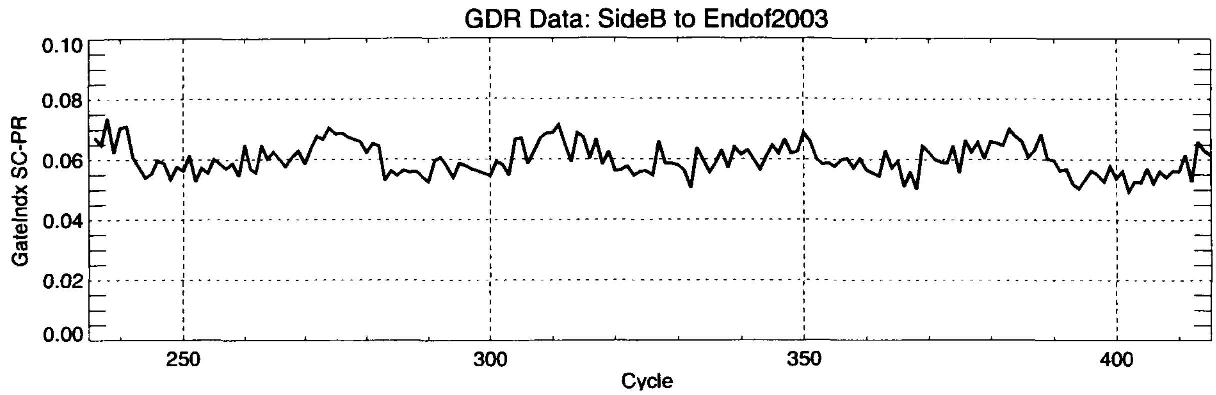


Figure 4-3 Cycle-Average Gate Index Delta

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 year 2003. This plot provides a quick indication whether the sigma0 calibration has been maintained to within 0.25 dB. Unlike the previous two figures, however, this figure is not a pure indication of system health, because both the Ku- and the C-band sigma0 calibrations have been 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 have 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.

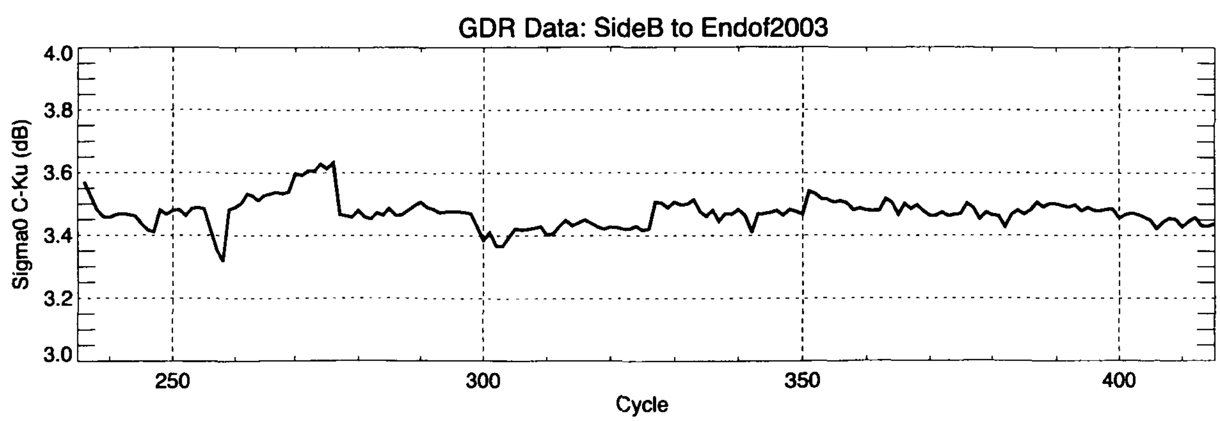


Figure 4-4 Cycle-Average Sigma0 Delta in dB

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 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

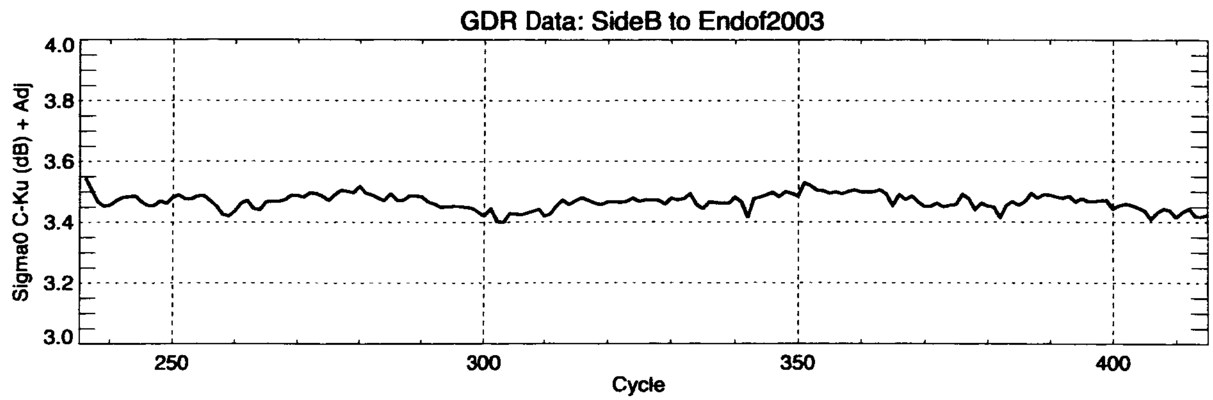


Figure 4-5 Cycle-Average Sigma0 Delta in dB with Cal Table Adjustment

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.

4.3 Tape Recorder (TR) Degradation

Due to the effects of ageing, the capabilities of TOPEX's three onboard tape recorders, designated as TR-A, TR-B, and TR-C, have been in decline. Prior to the degradation in performance, the baseline number of Hours-in-Track in a 24-hour time period for Side B had been generally 23.85 hours per day, or 99.4%. The overall average hours per day was 23.6 (98%) prior to 2002. The pre-launch goal for data acquisition was 90%.

In May 2000 (approximately 450 days since Side B turn-on), Tape Recorder B (TR-B) began to degrade, and the hours in track started dropping to about 23.40 hours. JPL OPS implemented procedures to augment data recovery by implementing realtime downloads. In September 2001 (approximately at 954 days), TR-B was removed from the recorder sequence. During this time, TR-A started to degrade and was eventually deactivated at the end of October 2002 (approximately at 1356 days). This left only one active recorder, TR-C, which is being augmented by realtime downloads.

With the availability of only one recorder and with the realtime downloads, the overall average number of hours-in-track was 22.8 (95%) in 2002. During 2003, the overall average number of hours-in-track dropped to 21.8 (91%). The decrease in the average hours-in-track is the result of the loss of data due to tape position transients during playbacks. Figure 4-6 provides the history trend of Hours-in-Track since the turn-on of Side B.

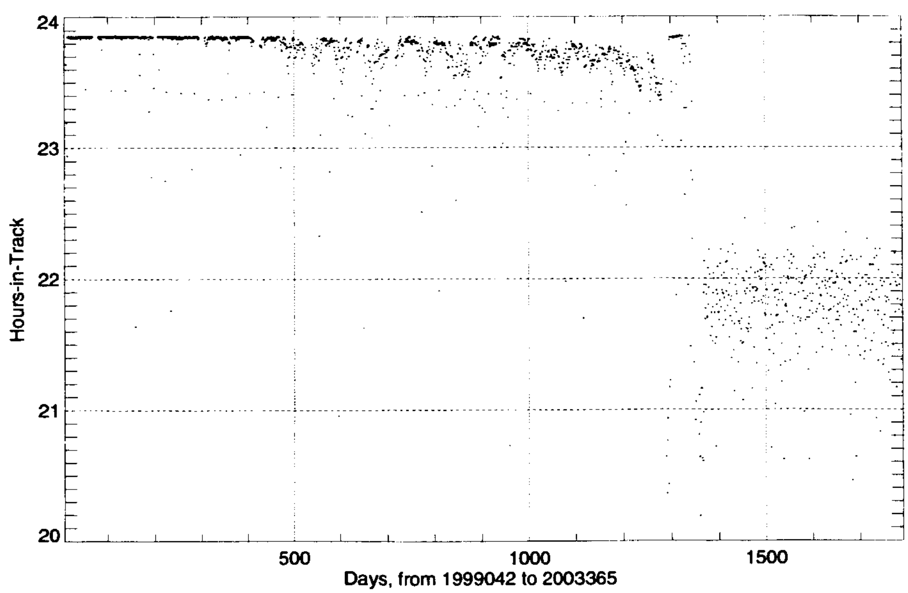


Figure 4-6 Hours-in-Track from Beginning of Side B

Section 5

TOPEX/POSEIDON Follow-On, JASON-1

JASON-1 is designated as 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 has analyzed the JASON-1 GDR data both during and subsequent to the tandem mission, and has 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.

In April 2003, a new version of the JASON-1 science software was implemented. Since that time, the new software was used to generate current products and reprocess previous products. This has resulted in the JASON-1 statistics, Cycle 2 to Cycle 35, in last year's TOPEX Radar Engineering Assessment Report, Update: Side B Turn-On to January 1, 2003, May 2003 to be different than what is stated in this report. Table 5-1 provides a summary of the original and reprocessed results. Attachment B contains the April 2003 memo describing the new software update.

Table 5-1 Summary of Original and Reprocessed Results

JASON			TOPEX
Sample Products	Original IGDR Results	Reprocessed IGDR Results	IGDR Results
SWH Ku	2.68	2.72	2.82
SWH C	2.69	2.74	2.86
Sigma0 Ku	11.44	13.62	11.18
Sigma0 C	15.17	15.32	14.66
Sea Lvl Anomaly	0.1296	0.1830	0.0115

5.1 Range Measurement Noise Comparison

The JASON-1 altimeter noise levels have been 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, June 2001.

The noise level estimates provided in Table 5-2 are 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 for JASON-1 is estimated to be about 2.80 cm and for TOPEX, is estimated to be about 1.80 cm. These estimates are the average of all the cycles with each cycle having equal weight.

For a typical corresponding JASON/TOPEX cycle, there are approximately 70% more JASON data points than TOPEX data points. Primarily, the difference in the number of data points is 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 in Table 5-2, 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.

Table 5-2 JASON/TOPEX Range Measurement Noise Level (NL) Comparison

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	0.196	1.010	1.781	3.073	3172	360

Table 5-2 JASON/TOPEX Range Measurement Noise Level (NL) Comparison (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
18	5230	3.219	2.802	0.000	0.000				361
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
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 5-2 JASON/TOPEX Range Measurement Noise Level (NL) Comparison (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

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 5-1. The JASON-1 SWH Ku average of all the cycles is 2.72 m and the average SWH Ku for TOPEX is 2.82 m, a difference of 0.10 m. The JASON-1 SWH C averages of all the cycles is 2.74 m and the average SWH C for TOPEX is 2.86 m, a difference of 0.12 m. Figure 5-2 depicts the per-cycle difference between the JASON-1 and TOPEX SWH, for both Ku-Band and C-Band.

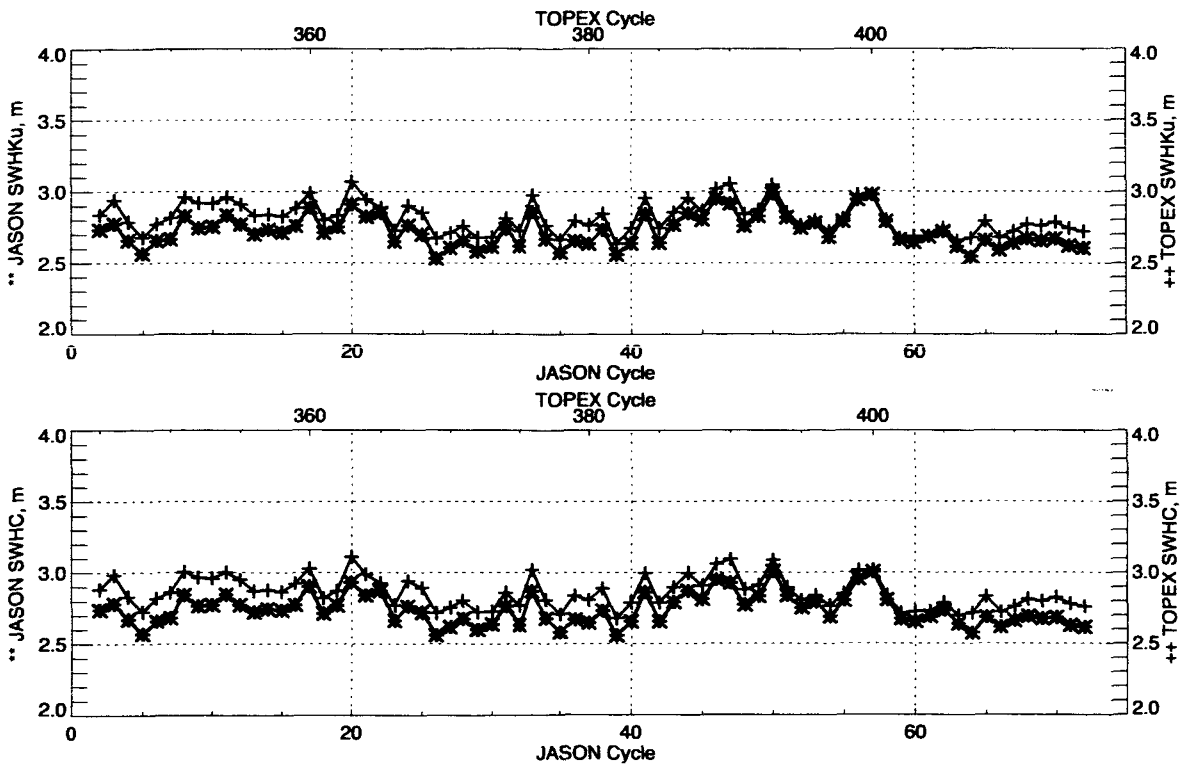


Figure 5-1 JASON/TOPEX Significant Wave Height Comparison

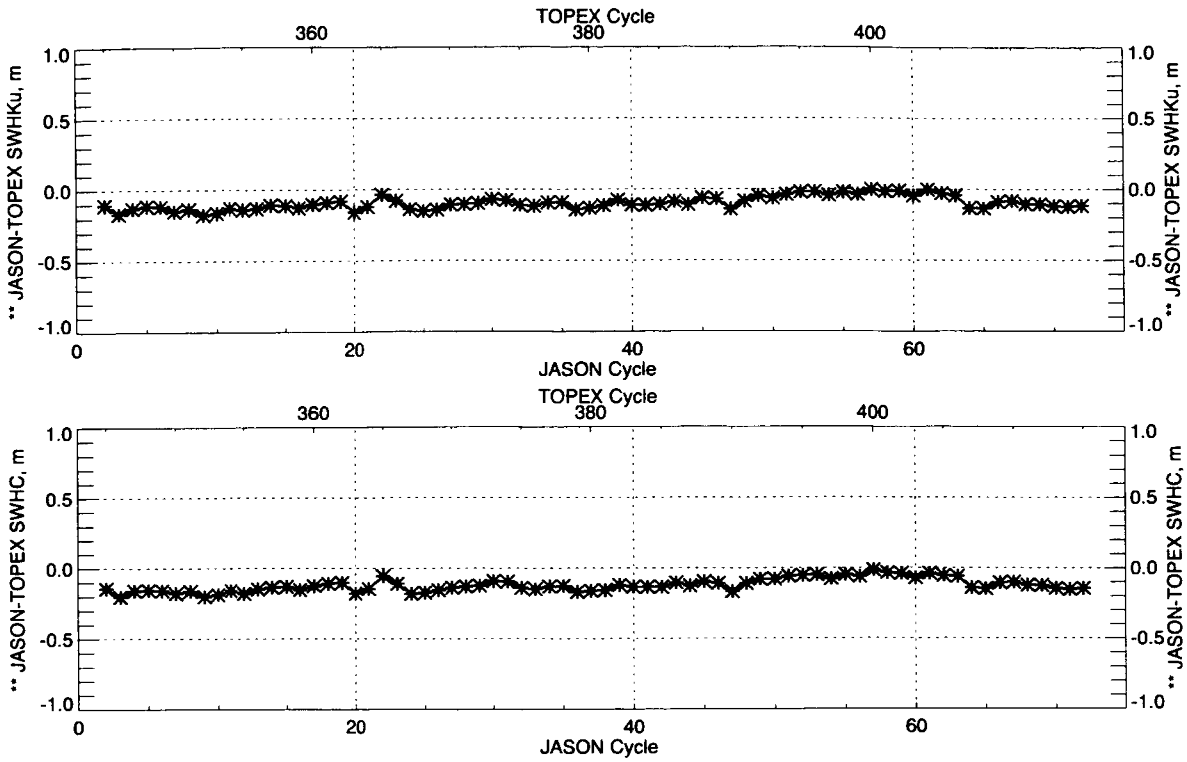


Figure 5-2 JASON/TOPEX SWH Delta in Meters

Figure 5-3 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 4-9.

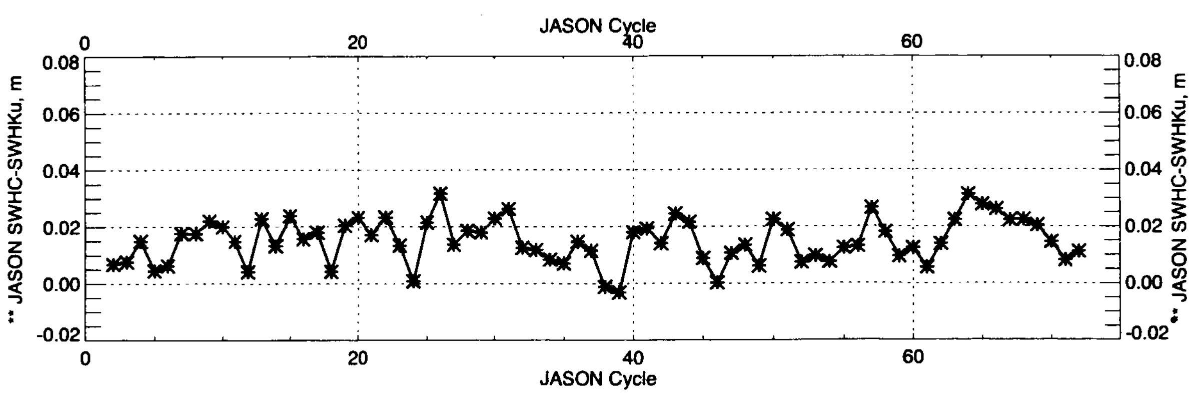


Figure 5-3 JASON Cycle-Average SWH Delta in Meters

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 5-4. The JASON-1 Ku Sigma0 average is 13.62 dB, and the Ku Sigma0 average for TOPEX is 11.18 dB, a difference of 2.44 dB. The C Sigma0 average for JASON is 15.32 dB, and the C Sigma0 average for TOPEX is 14.66 dB, a difference of 0.66 dB, and again the JASON-1 value is larger. Figure 5-5 shows the per-cycle difference between the JASON-1 and TOPEX sigma0, for both Ku-Band and C-Band.

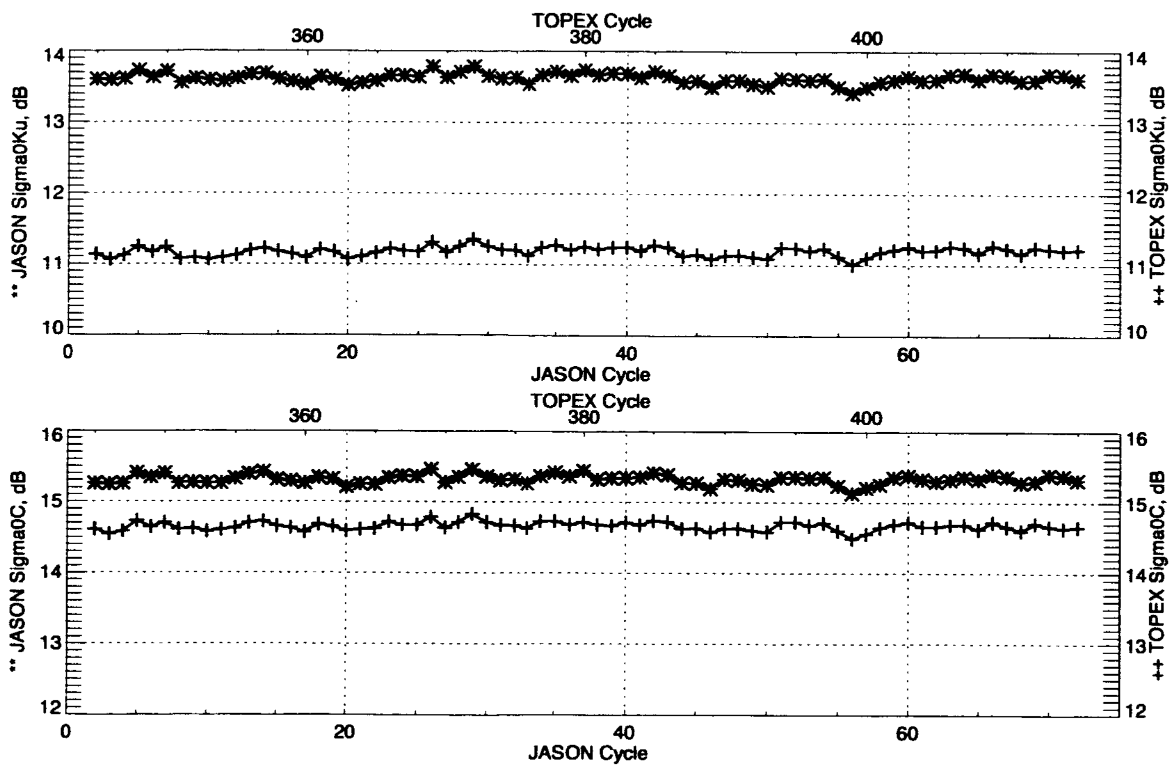


Figure 5-4 JASON/TOPEX Sigma Naught Comparison

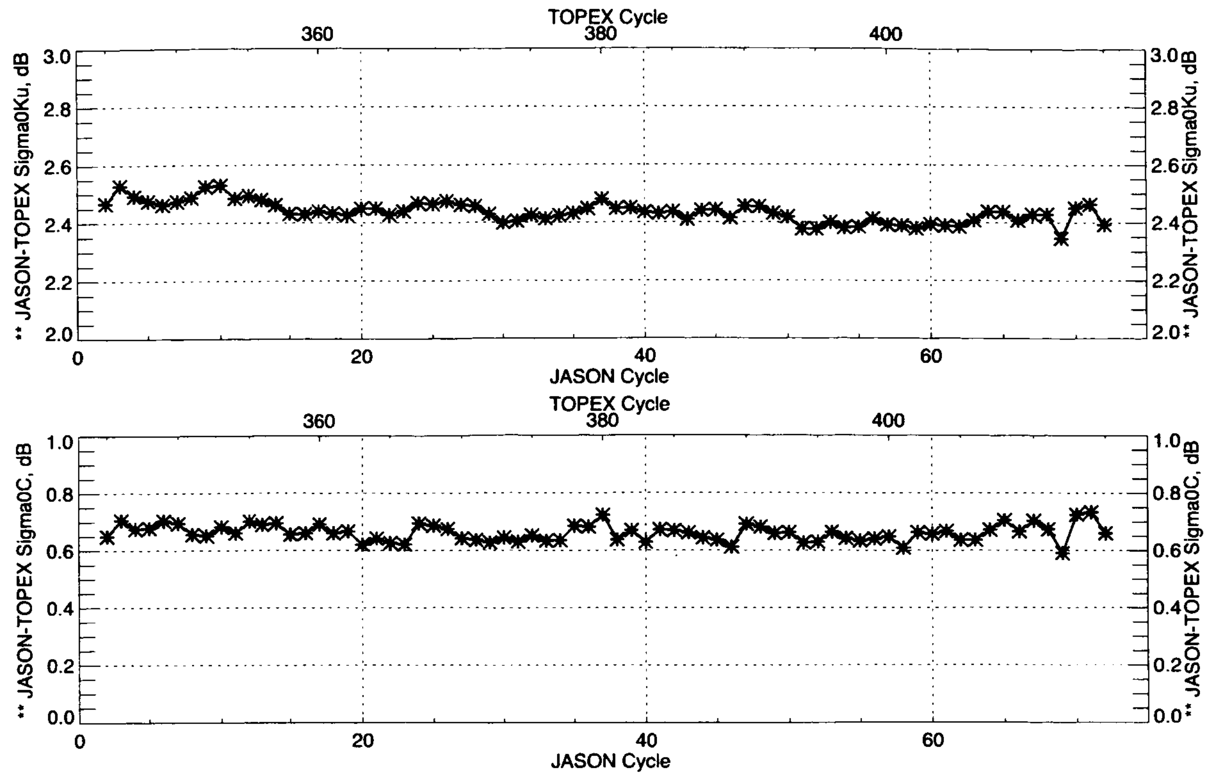


Figure 5-5 JASON/TOPEX Sigma0 Delta in dB

Figure 5-6 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 4-10, and in Figure 4-5, page 4-11 that shows the Sigma0 difference based on the best current estimates of Sigma 0 Cal Table.

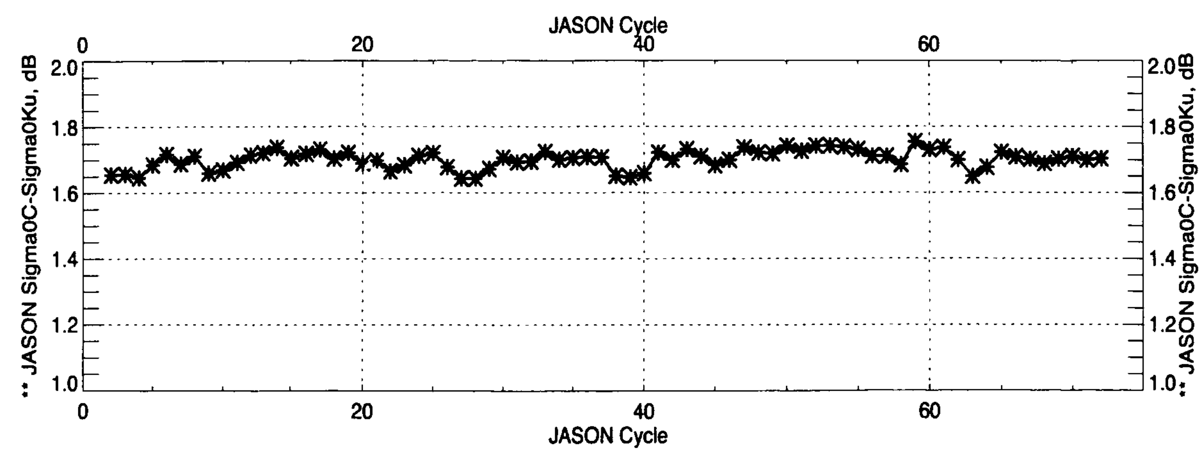


Figure 5-6 JASON Cycle-Average Sigma0 Delta in dB

5.4 Sigma Naught vs. Significant Wave Height Comparison

The upper plot in Figure 5-7 depicts TOPEX and JASON-1 Sigma0 for Ku-Band vs. the corresponding SWH. The lower plot in Figure 5-7 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.

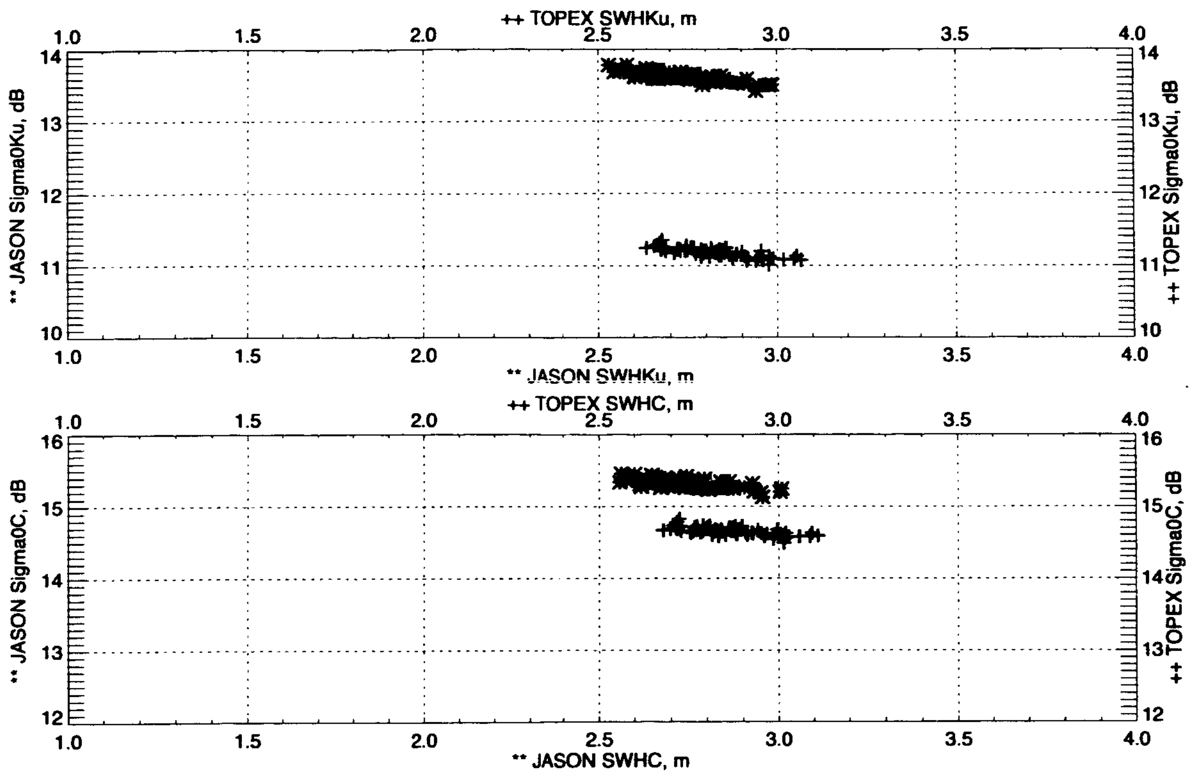


Figure 5-7 JASON/TOPEX Sigma0 vs. SWH Comparison

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, excluding the JASON Cycle 5 outlier, is 0.1830 meters, and the average residual sea surface height for TOPEX is 0.0115 meters.The per-cycle JASON-1 and TOPEX estimates, based on 60-second averages, are plotted in Figure 5-8.

During the 21-cycles of tandem operations, the JASON-1 sea level anomalies are approximately 17.4 cm higher than TOPEX. Subsequent to the tandem operations, the differences have decreased slightly, to about 16.8 cm. The per-cycle JASON-minus-TOPEX sea surface height difference are plotted in Figure 5-9.

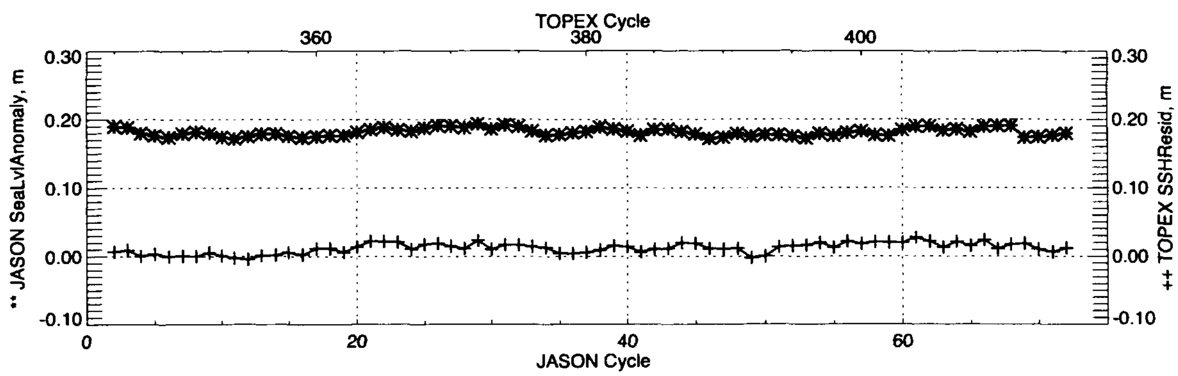


Figure 5-8 JASON-SLA/TOPEX-SSHRES Comparison

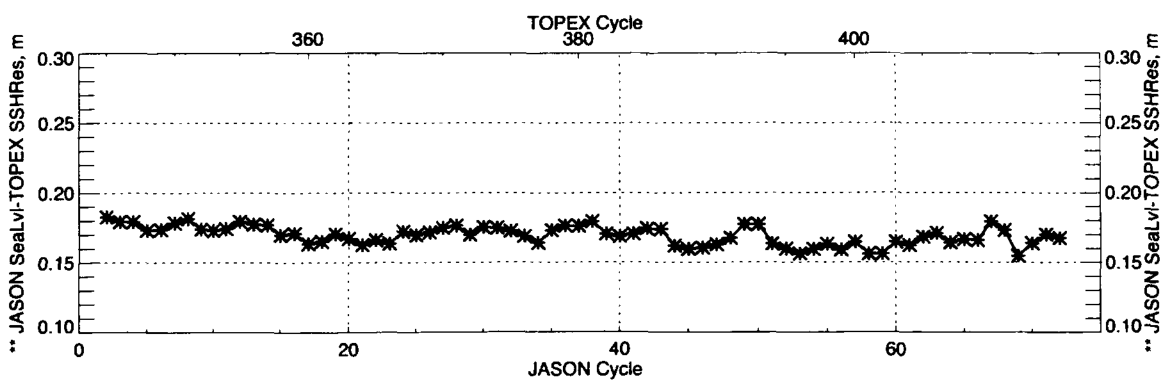


Figure 5-9 JASON-SLA/TOPEX-SSHRES Delta in Meters

Section 6

Engineering Assessment Synopsis

6.1 Performance Overview

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 is now the operational altimeter; however, Side A could be turned back on if needed.

Side A performance significantly surpassed all its pre-launch specifications, including its length of service. Based on our performance analysis and based on the reports of science investigators, Side B is performing as well as, or perhaps even better than, Side A.

The amount of ground-collected TOPEX NRA data on a daily basis has been diminished by the performance degradation of the onboard tape recorders. Since the time of last year's Engineering Assessment Report, the overall average hours per day have decreased from 95% to 91%, but the collection level is still bordering on the prelaunch goal of 90%.

The TOPEX NRA Cal mode range has started showing oscillations and has been documented in several sections of this report. At this time, we do not have a concern relative to the instrument, but this calibration range oscillation may have minor performance effects, at the few-millimeter level, on the data.

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

Since last year's TOPEX Radar Altimeter Engineering Assessment Report Update, the JASON geophysical data has been reprocessed with new science software. The results generated by the new software have improved. The reprocessed results for JASON to TOPEX comparisons exhibit excellent agreement.

The TOPEX NRA completed its orbit maneuver transfer to its new orbit on September 16, 2002, during cycle 368. To date we have not noticed any significant changes in instrument performance. Global statistics remain consistent with previous years.

We are continuing, on a daily basis, our performance assessment of the TOPEX Side B and Jason-1 altimeters.

Appendix A
Cumulative Index of Studies

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, May 2003.

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, May 2003.

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

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

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, 2003,* NASA/TM-2004-212236, Volume 17, May 2003.

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, 2003,* NASA/TM-2004-212236, Volume 17, May 2003.

Land-to-Water Acquisition Times - *TOPEX Radar Altimeter Engineering Assessment Report, Update: From Side B Turn-On to January 1, 2003,* NASA/TM-2004-212236, Volume 17, May 2003.

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

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Appendix B
Ku CAL-1 Range Toggling

MEMO TO JASON-1 PIs and CoIs - APRIL 8, 2003

P. VINCENT (CNES), S.D. DESAI (JPL), N. PICOT (CNES), K. CASE (JPL)

THE FIRST GENERATION OF IGDRS AND GDRS PRODUCTS TO BE MADE AVAILABLE AFTER COMPLETION OF THE JASON-1 VERIFICATION PHASE

1. PURPOSE

The document describes the various elements that are related to the first generation of OSDR, IGDR, GDR, and SGDR data products to be publicly distributed to the science community at large (including PIs and CoIs).

2. UPDATES OF THE SCIENCE SOFTWARE

The following sections describe the list of corrections and improvements that have been applied to the science processing software to generate the OSDR, IGDR and (S)GDR data products from the beginning of cycle 46.

The same corrections/improvements will of course be applied to reprocessed (S)GDRs from cycles 1 to 45.

Please note that the distribution of the new generation of IGDR products will start on April 14, 2003, with the cycle 46 GDRs to be released approximately 30 days after the end of cycle 46. See specific section dedicated to data product distribution for more information on this topic.

3. UPDATE OF THE LEVEL 1.0 TELEMETRY PROCESSING

An updated version of the JMR (Jason-1 Microwave Radiometer) level 1.0 software using adjusted sets of coefficients to derive antenna temperatures has been implemented.

This software also improves the orbit interpolation to locate the JMR measurements, using a Lagrangian interpolator.

4. UPDATE OF SCIENCE PROCESSING

Version 6.0 of the SSALTO/CMA science processing software is the latest update realized to deal with the level 1b and level 2 processing of converted telemetry.

According to the recommendations derived from the New Orleans October 2002 SWT (Science Working Team) meeting and following the conclusions of the December 2002 AGU « Jason-1 GDR Recommandation meeting », the science processing software has been updated with the following elements.

4.1 DATA PRODUCT ANOMALIES THAT HAVE BEEN SOLVED

IGDRs and GDRs to be issued from cycle 46, as well as reprocessed (S)GDRs (cycle 1 to 45) will have the following corrections for anomalies discovered by various members of the SWT. These are:

- Define the total geocentric tide as the sum of the 3 terms (semidiurnal and diurnal ocean tide + semidiurnal and diurnal loading tide + equilibrium long period ocean tide)

Also, concerning OSDRs:

- Correct for the anomaly concerning the window indexes to compute the mispointing angle in the OSDR products.

To avoid any confusion for PIs and CoIs that have analyzed the Jason-1 data from the verification phase, let us add that all of the corrections that have already been implemented since version 5.5 of the science processing software have of course also been taken into account in the new version (6.0) of the science software. These are:

- Use of averaged Brightness Temperatures (TBs) instead of unaveraged ones in the computation of the JMR wet troposphere correction.
- Computation of the RMS of the 20 Hz elementary SWH
- Anomaly related to instrumental correction on the 20 Hz ranges
- Anomaly dealing with the correction of sigma0 in the OSDR product

4.2 SCIENCE SOFTWARE IMPROVEMENTS AGREED DURING THE FINAL VERIFICATION MEETING

The following science software improvements have been implemented according to the recommendations of the SWT during the October 2002 New Orleans meeting.

- Implementation of a newly adjusted non-parametric table for the Jason-1 sea-state bias (SSB)
- Implementation of calibrated JMR coefficients at level 1b and at geophysical level 2.
- Correct atmospheric attenuation on sigma0 from 1-way to 2-way contribution.
- Addition of a range bias to the GSFC MSS to ensure consistency with the reference atmospheric pressure that is used for the Jason-1 processing of the inverse barometer effect.
- Use of analyzed meteorological fields in IGDRs instead of forecast fields.
- Remove DORIS TEC and DORIS ionosphere estimates from Jason-1 IGDRs
- Take into account the MQE (Mean Quadratic Error) criterium in the altimetric compression algorithm
- Use the "biased" sigma0 in the geophysical algorithms that need sigma0 as inputs, but have the "unbiased sigma0" in the products (Note that the biases applied to the Jason-1 sigma0 to have them consistent with the Topex sigma0 are respectively -2.26 dB in the Ku band and –0.28 dB in the C band)
- Have the ground retracking algorithm configured so that the waveform off-nadir angle estimated at the OSDR level be used as input to the IGDR processing.
- Change the format of the SGDR product to have waveforms coded on 2 bytes (instead of 4) and include additional corrections in the product.

4.3 IMPROVEMENTS STILL TO BE PERFORMED

The following corrections/improvements were identified during the New Orleans SWT meeting but are not yet implemented in the science software:

1. Correct interpolation of JMR brightness temperatures and wet path delays (PDs), as well as JMR flagging, in land/sea transitions.
2. An investigation is still underway to check the accuracy of the GOT99 ocean tide model as it is computed by the Jason science software.
3. Fine tuning of post-launch altimeter instrumental correction tables using the in-orbit low pass filters
4. Check the reason why OSDR SWH are always less than 12.7 m
5. Include a flag for bad SWH in the OSDR product

Item 1 shall improve use of the radiometer data in the vicinity of coasts for on site calibration purposes. To satisfy such use of the data, the best effort is being given to have this change implemented as soon as possible.

Item 3 will be tested in the near future to evaluate the impact of the altimeter correction tables onto the geophysical parameters that are retrieved from ground retracking.

Items 4 and 5 are presently under study to provide operational users with « clean » significant waveheight (SWH) distributions.

5. USER INFORMATION DOCUMENTS

5.1 UPDATED USER HANDBOOK

An updated version of the IGDR/GDR User Handbook has been produced.

It will be available through ftp and from the AVISO and PO.DAAC web sites, on Monday April 14, 2003.

5.2 RECOMMENDING A RANGE BIAS FIGURE

A recommendation of the December 2002 « Jason-1 GDR Recommendation meeting » stated that the range bias figure to be considered is the one derived from the on site calibration experiments.

Following are two tables provided by B.J. Haines and Y. Menard to summarize the main range bias figures.

Using the Jason IGDR orbits:

SITE	N	σ	Mean (mm)	Median (mm)
Harvest	22	42	+133 ± 9	+129 ± 9
Corsica	23	45	+120 ± 9	+119 ± 9
Bass Strait	5	9	+147 ± 4	+152 ± 4
ALL	50	42	+129 ± 6	+128 ± 6

Using GPS reduced-dynamic orbits:

SITE	N	σ	Mean (mm)	Median (mm)
Harvest	22	34	+134 ± 7	+130 ± 7
Corsica	23	37	+130 ± 8	+131 ± 8
Bass Strait	5	26	+131 ± 11	+146 ± 11
ALL	50	34	+132 ± 5	+131 ± 5

These 2 tables result from fifty site overflights (N being the number of overflights corresponding to each site) using the best available JMR data and the sea-state bias correction that is implemented in the updated operational science processing (CMA v6.0) of the I/GDRs.

5.3 OSDR/IGDR/GDR PRODUCT QUALITY

Two oral presentations given during the December AGU 2002 meeting and during the EGS-AGU-EUG 2003 meeting will be made available on the AVISO and PO.DAAC web sites.

A short paper from P. Vincent et al. (2003) explaining some of the results of the verification phase in terms of Jason-1 data quality, to be published in Issue 9 of the AVISO Newsletter, will also be made available on the AVISO and PO.DAAC web sites.

Last, a more extensive paper displaying a variety of verification results will be put together in the coming weeks and will be made available to the users through the AVISO and PO.DAAC web sites.

6. ERROR BUDGET TABLE AT THE END OF THE CALVAL PHASE

	OSDR (3 HOURS)		IGDR (3 days)		GDR (30 DAYS)	
	SPEC	PERFO	SPEC	PERFO	SPEC	PERFO
Altimeter noise (cm) (H1/3=2m, σ=11dB) 1Hz	*2.5*	**1.8**	*1.7*	**1.6**	*1.7*	**1.6**
Sea State Bias (%H1/3)	*	*	*1.2%*	**1% ****	*1.2%*	**1% ****
Ionosphere (cm)	*	*	*0.5****	**0.5*****	*0.5****	**0.5*****
Dry Tropo (cm)	*	*	*0.7*	**0.7**	*0.7*	**0.7**
Wet Tropo (cm)	*1.2*	**1.2**	*1.2*	**1.2**	*1.2*	**1.2**
Corrected Range (RSS, cm) (H1/3=2m, σ=11dB) 1Hz	*	*	*3.3*	**3**	*3.3*	**3**
Orbit (radial component) (cm)	*30*	**20**	*4*	**2.5**	*2.5*	**1.5**
Corrected Sea Surface Height (RSS,cm) (H1/3=2m, σ=11dB) 1 Hz	*	*	*5.2*	**3.9**	*4.1*	**3.3**
Wave Height H1/3 (m or %H1/3, whichever is greater)	*0.5 or 10%*	**0.5 ***** or 10%**	*0.5 or 10%*	**0.4 **** or 10%**	*0.5 or 10%*	**0.4 **** or 10%**
Wind Speed (m/s)	*2*	**1.6 *******	*1.7*	**1.5 ******	*1.7*	**1.5 ******

* not available on the OSDR, but can be computed from available parameters

** improvement studies in progress

*** after filtering over 100 km

**** after bias calibration

***** after bias calibration and elimination of spurious data

7. ITEMS TO BE CONSIDERED FOR AN IMPROVED 2-ND GENERATION OF PRODUCTS

The following elements have already been agreed upon by the members of the SWT and will be addressed as future improvements to be applied to the science processing software.

They are listed in the present document for information only.

They will be the subject of a dedicated working plan with the objective of having them addressed in a 2-nd generation of Jason GDR products.

These are :

- Implementation of FES2002 or 2003 and updated GOT tide models
- Implementation of the improved global and along-track Mean Sea-Surface (MSS) models
- Handling of air tides
- Provide a correction for the aliasing of the high frequency sea-surface height variability in the data products
- Optimize ground retracking algorithm and associated constants and look-up tables
- Implement new findings dealing with SSB
- Implement updated tables (already provided by J. Tournadre, but not yet tested operationally) for rain flagging
- Others, TBD

To implement such improvements and create an improved 2-nd generation of GDR products, a schedule will be prepared on the basis of recommendations from the SWT and will be discussed at Jason-1 Project level.

8. DISTRIBUTION OF DATA PRODUCTS

8.1 OSDR PRODUCTS

OSDR data products are made available by NASA/PO DAAC and CNES/SSALTO-AVISO using the File System Protocol (ftp). Users are cautioned that some OSDR data from cycle 46 onwards are likely to be generated with the current (older) version of the science software (CMA v5.5), while the new software (CMA v6.0) is being installed into the operational processing system. The header of the OSDR data products provides information about the version of the generating software.

8.2 IGDR DATA PRODUCTS

8.2.1 DATA ACQUIRED PRIOR TO CYCLE 46

No reprocessed IGDRs will be disseminated.

8.2.2 DATA ACQUIRED AFTER START OF CYCLE 46

IGDR data products are made available by NASA/PO.DAAC and CNES/SSALTO-AVISO using the File System Protocol (ftp).

From Monday 14 April, IGDR data products that have been generated with the new science software (CMA v6.0) will start flowing to users: first data products will correspond to the first few days of measurements at the beginning of cycle 46.

By Monday 14 April, a dedicated message from N. Picot (AVISO) and K. Case (PO.DAAC) will recall the IP addresses where to find the data.

8.3 GDR PRODUCTS

The distribution scheme of all GDR products involves ftp access to products at NASA/PO.DAAC and CNES/SSALTO-AVISO.

Media will also be generated by CNES/SSALTO-AVISO to distribute GDRs.

All GDR products will be generated with the new science software (CMA v6.0).

In terms of GDR data latency:

- The distribution of GDR products from cycle 46 onwards is based on the same data product latency as for TOPEX/POSEIDON (approximately 30 days after the end of the cycle).
- A schedule is under construction concerning reprocessing of cycle 1 to 45. The current plan is to begin reprocessing in April and have it completed in September 2003. Reprocessed GDR products will be gradually made available once they have been processed and validated.

A dedicated message will be sent early in May 2003 to provide details on the schedule of GDR delivery.

Appendix C
TOPEX Range Bias Changes

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

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
51	20	-0.076	+0.723

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
78	20	-3.715	+0.444
80	19	-3.059	+0.350

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
107	20	-4.509	+0.207
108	19	-3.955	+0.196
109	19	-3.808	+0.168

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
134	20	-1.764	+0.184
135	20	-2.604	+0.710
136	20	-2.878	+0.371
137	21	-1.968	+0.904

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
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

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
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

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
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

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
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

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
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

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
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

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
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

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
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

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
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

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

Cycle #	Count	Avg dR(comb), mm	StDev dR(comb), mm
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
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

Appendix D
TOPEX Side B Sigma0 Cal

Table D-1 TOPEX Side B Sigma0 Cal Table Values

	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					

Table D-1 TOPEX Side B Sigma0 Cal Table Values

	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
257	+0.45	+0.64	+0.347	+0.635	-0.103	-0.005
258	+0.45	+0.64	+0.338	+0.636	-0.112	-0.004
259	+0.27	+0.64	+0.328	+0.637	+0.058	-0.003
260	+0.27	+0.64	+0.319	+0.637	+0.049	-0.003
261	+0.27	+0.64	+0.310	+0.638	+0.040	-0.002
262	+0.24	+0.64	+0.300	+0.639	+0.060	-0.001
263	+0.24	+0.67	+0.291	+0.640	+0.051	-0.030
264	+0.24	+0.67	+0.281	+0.640	+0.041	-0.030
265	+0.24	+0.67	+0.272	+0.641	+0.032	-0.029
267	+0.21	+0.67	+0.253	+0.643	+0.043	-0.027
268	+0.21	+0.67	+0.244	+0.644	+0.034	-0.026
269	+0.21	+0.67	+0.234	+0.644	+0.024	-0.026
270	+0.18	+0.70	+0.235	+0.645	+0.055	-0.055
271	+0.18	+0.70	+0.236	+0.646	+0.056	-0.054
272	+0.18	+0.70	+0.237	+0.647	+0.057	-0.053
273	+0.18	+0.70	+0.238	+0.647	+0.058	-0.053
274	+0.15	+0.70	+0.239	+0.648	+0.089	-0.052
275	+0.15	+0.70	+0.240	+0.649	+0.090	-0.051
276	+0.15	+0.70	+0.241	+0.650	+0.091	-0.050
277	+0.21	+0.58	+0.242	+0.651	+0.032	+0.071
279	+0.21	+0.58	+0.244	+0.652	+0.034	+0.072
280	+0.21	+0.58	+0.244	+0.653	+0.034	+0.073
281	+0.21	+0.58	+0.245	+0.654	+0.035	+0.074
282	+0.21	+0.58	+0.246	+0.655	+0.036	+0.075

Table D-1 TOPEX Side B Sigma0 Cal Table Values

	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
283	+0.21	+0.61	+0.247	+0.655	+0.037	+0.045
284	+0.21	+0.61	+0.248	+0.656	+0.038	+0.046
285	+0.21	+0.61	+0.249	+0.657	+0.039	+0.047
286	+0.21	+0.61	+0.250	+0.658	+0.040	+0.048
287	+0.21	+0.61	+0.251	+0.658	+0.041	+0.048
288	+0.21	+0.61	+0.252	+0.659	+0.042	+0.049
290	+0.18	+0.61	+0.254	+0.661	+0.074	+0.051
291	+0.18	+0.61	+0.255	+0.662	+0.075	+0.052
292	+0.18	+0.61	+0.256	+0.662	+0.076	+0.052
293	+0.18	+0.61	+0.257	+0.663	+0.077	+0.053
294	+0.18	+0.61	+0.258	+0.664	+0.078	+0.054
295	+0.18	+0.61	+0.258	+0.665	+0.078	+0.055
296	+0.18	+0.61	+0.259	+0.665	+0.079	+0.055
297	+0.18	+0.61	+0.260	+0.666	+0.080	+0.056
298	+0.18	+0.61	+0.261	+0.667	+0.081	+0.057
300	+0.24	+0.61	+0.263	+0.669	+0.023	+0.059
301	+0.24	+0.61	+0.264	+0.669	+0.024	+0.059
302	+0.24	+0.61	+0.265	+0.670	+0.025	+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	+0.682	+0.031	+0.042
309	+0.24	+0.64	+0.271	+0.686	+0.031	+0.046

Table D-1 TOPEX Side B Sigma0 Cal Table Values

	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
310	+0.24	+0.64	+0.272	+0.689	+0.032	+0.049
311	+0.24	+0.64	+0.273	+0.692	+0.033	+0.052
312	+0.24	+0.64	+0.274	+0.695	+0.034	+0.055
313	+0.24	+0.64	+0.275	+0.698	+0.035	+0.058
314	+0.24	+0.64	+0.276	+0.702	+0.036	+0.062
315	+0.24	+0.64	+0.277	+0.705	+0.037	+0.065
316	+0.24	+0.64	+0.278	+0.708	+0.038	+0.068
317	+0.24	+0.64	+0.279	+0.711	+0.039	+0.071
318	+0.24	+0.64	+0.280	+0.715	+0.040	+0.075
319	+0.24	+0.64	+0.281	+0.718	+0.041	+0.078
320	+0.24	+0.64	+0.282	+0.721	+0.042	+0.081
321	+0.24	+0.64	+0.283	+0.724	+0.043	+0.084
322	+0.24	+0.64	+0.284	+0.728	+0.044	+0.088
323	+0.24	+0.64	+0.285	+0.731	+0.045	+0.091
324	+0.24	+0.64	+0.285	+0.734	+0.045	+0.094
325	+0.24	+0.64	+0.286	+0.737	+0.046	+0.097
326	+0.24	+0.64	+0.287	+0.740	+0.047	+0.100
327	+0.27	+0.76	+0.288	+0.744	+0.018	-0.016
328	+0.27	+0.76	+0.289	+0.747	+0.019	-0.013
329	+0.27	+0.76	+0.290	+0.750	+0.020	-0.010
330	+0.27	+0.76	+0.291	+0.753	+0.021	-0.007
331	+0.27	+0.76	+0.292	+0.757	+0.022	-0.003
332	+0.27	+0.76	+0.293	+0.760	+0.023	-0.000
333	+0.27	+0.76	+0.294	+0.763	+0.024	+0.003

Table D-1 TOPEX Side B Sigma0 Cal Table Values

	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
334	+0.27	+0.76	+0.295	+0.766	+0.025	+0.006
335	+0.27	+0.76	+0.296	+0.769	+0.026	+0.009
336	+0.27	+0.76	+0.297	+0.773	+0.027	+0.013
337	+0.30	+0.76	+0.297	+0.776	-0.003	+0.016
338	+0.30	+0.79	+0.297	+0.779	-0.003	-0.011
339	+0.30	+0.79	+0.297	+0.782	-0.003	-0.008
340	+0.30	+0.79	+0.297	+0.786	-0.003	-0.004
341	+0.30	+0.79	+0.297	+0.789	-0.003	-0.001
342	+0.30	+0.79	+0.297	+0.792	-0.003	+0.002
343	+0.30	+0.79	+0.297	+0.795	-0.003	+0.005
344	+0.30	+0.79	+0.297	+0.799	-0.003	+0.009
345	+0.30	+0.79	+0.297	+0.802	-0.003	+0.012
346	+0.30	+0.79	+0.297	+0.805	-0.003	+0.015
347	+0.30	+0.79	+0.297	+0.805	-0.003	+0.015
348	+0.30	+0.79	+0.297	+0.805	-0.003	+0.015
349	+0.30	+0.79	+0.297	+0.805	-0.003	+0.015
350	+0.30	+0.79	+0.297	+0.805	-0.003	+0.015
351	+0.30	+0.82	+0.297	+0.805	-0.003	-0.015
352	+0.30	+0.82	+0.297	+0.805	-0.003	-0.015
353	+0.30	+0.82	+0.297	+0.805	-0.003	-0.015
354	+0.30	+0.82	+0.297	+0.805	-0.003	-0.015
355	+0.30	+0.82	+0.297	+0.805	-0.003	-0.015
356	+0.30	+0.82	+0.297	+0.805	-0.003	-0.015
357	+0.30	+0.82	+0.297	+0.805	-0.003	-0.015

Table D-1 TOPEX Side B Sigma0 Cal Table Values

	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
358	+0.33	+0.82	+0.297	+0.805	-0.033	-0.015
359	+0.33	+0.82	+0.297	+0.805	-0.033	-0.015
360	+0.33	+0.82	+0.297	+0.805	-0.033	-0.015
362	+0.33	+0.82	+0.297	+0.805	-0.033	-0.015
363	+0.33	+0.85	+0.297	+0.805	-0.033	-0.045
- -	these values remain constant for cycles 363 through 415					
415	+0.33	+0.85	+0.297	+0.805	-0.033	-0.045

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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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 end of calendar year 2003 and includes the performance assessment of Jason-1, the TOPEX follow-on mission, launched on December 7, 2001.

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