NASA/TM—2003–209984/VER. 1/VOL. 4

GEOSAT Follow-On (GFO) Altimeter Document Series

Volume 4
GFO Altimeter Engineering Assessment Report

Update:
The First 43 Cycles Since Acceptance
November 29, 2000 to November 30, 2002

Version 1

D. W. Hancock, III, G. S. Hayne

D. W. Lockwood, R. L. Brooks

April 2003

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Acknowledgments

This document includes contributions by the following members of the Wallops Flight Facility GFO Team:

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  WFF GFO Altimeter Verification Manager
- George Hayne (NASA GSFC/WFF)
- Anita Brenner (Raytheon ITSS/Greenbelt)
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Foreword

The Navy's Geosat Follow-On (GFO) Mission, launched on February 10, 1998, is an altimetric satellite with heritage that includes Seasat, Geosat, TOPEX/POSEIDON (T/P), and ERS-1. Data derived from these missions has and will lead to improvements in the knowledge of ocean circulation, ice sheet topography, and climate change. In order to capture the maximum amount of information from the altimetric data, accurate altimeter calibrations are required for the GFO civilian data set that NOAA will produce. NASA/Goddard Space Flight Center/Wallops Flight Facility (GSFC/WFF) has provided these calibrations for the Seasat, Geosat and T/P missions, and is doing the same for GFO.

Wallops' multiple roles with regard to GFO are:

- NASA Representative for Radar Altimeter Performance
- Calibration Collaboration
- Member of GFO Cal-Val Team
- Data distribution to members of Cal-Val Team
- Validate sensor-related corrections
- Provide corrections for sensor changes

For the latest updates on the performance of the GFO Radar Altimeter, and for accessing many of our reports, readers are encouraged to contact our WFF/GFO Home Page at http://gfo.wff.nasa.gov/.

This WFF GEOSAT Follow-On (GFO) Altimeter Engineering Assessment Report has been prepared by Raytheon/ITSS under Contract NAS5-00181 with the NASA Goddard Space Flight Center, Greenbelt, Maryland. This work was performed under the direction of David W. Hancock, III, WFF GFO Altimeter Verification Manager, Observational Science Branch, Laboratory for Hydrospheric Processes, NASA Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, Virginia. Mr. Hancock may be contacted at (757) 824-1238 (voice), hancock@osb1.wff.nasa.gov (e-mail), or (757) 824-1036 (fax).

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Section 1

Introduction

1.1 Identification of Document

The purpose of this document is to present and document GFO performance analyses and results. It is the third of a series of GFO performance documents, each of which update WFF's assessment results. This is the second Engineering Assessment Report since the initial report. This report extends the performance assessment since acceptance to 30 November 2002.

The initial GFO Altimeter Engineering Assessment Report, in March 2001, covered the GFO performance from Launch to Acceptance (10 February 1998 to 29 November 2000). The second of the series covered the performance from Acceptance to the end of Cycle 20 (29 November 2000 to 21 November 2001).

Since launch, we have performed a variety of GFO performance studies; Appendix A provides an accumulative index of those studies.

1.2 Definition of a GFO Cycle

Like its predecessor, GEOSAT, the GFO groundtrack has a repeat (+/-1 km) period of 17.05 days. For our analyses, the repeat periods are referred to as cycles, and are used as data dividers to assess sensor internal consistency, taking into account seasonal differences.

For simplification in tracking the performance of the satellite, the Navy is using exactly 17-day boundaries in the definition of a cycle. The first 17-day cycle after acceptance by the Navy is numbered 000, Cycle 000, and is used as a reference for the succeeding cycles. The 17-day cycle which started on December 16, 2000 (Julian day 2000352) is the beginning of the first evaluation cycle, Cycle 001, which ended on January 2, 2001 (Julian day 2001002). Each subsequent cycle is consecutively numbered.

1.3 Data Flow to/from Wallops

1.3.1 To Wallops

The daily near-real time GFO data flow from the Naval Oceanographic Office (NAVO), Altimetry Data Fusion Center (ADFC), Stennis Space Center, Bay St. Louis, MS, to Wallops Flight Facility (WFF) consists of:

- Science data without waveforms (ra_data)
- Science data with waveforms (ra_cal_data)
- Engineering data (eng_data)
- Water Vapor Radiometer data (wvr_data)
- Sensor data (sdr)

Additional data are forwarded by the Navy to Wallops as soon as it is available, consisting of:

- Navy Geophysical Data (ngdr)
- Operational Orbital Determination data (oodd)

1.3.2 From Wallops to Cal/Val Team Members

Wallops forwards the following GFO data types to the other members of the Cal/Val Team:

- Sensor data (sdr)
- Science data with waveforms (ra_cal_data)
- Operational Orbital Determination data (oodd)

Section 2

On-Orbit Instrument Performance (Cycles 00 through 42)

From the time of acceptance on November 29, 2000, to the end of this reporting period, the GFO altimeter has acquired a total of 731 days (43 cycles) of data.

The following subsections will illustrate that the altimeter tracking data have been internally consistent. The subsections discuss:

- internal calibrations
- cycle summaries
- key events

2.1 Internal Calibrations

The GFO's internal calibration mode has two submodes, designated CAL-1 and CAL-2. CAL-1 is designed to detect changes in the internal path delays, to measure range drift. CAL-1 also monitors changes in the receiver automatic change control (AGC); the altimeter's estimates of the ocean surface radar backscattering cross-section are obtained from the AGC values. The purpose of the second mode, CAL-2, is to characterize the response of the receiver and digital filter bank.

During CAL-1, a portion of the transmitter output is fed back to the receiver through a digitally controlled calibration attenuator and a delay line, whereupon the altimeter acquires and tracks the signal. Then, during CAL-2, the altimeter processes received thermal noise with no transmitted signal present, to characterize the waveform sampler response.

The GFO Project normally provides two internal calibrations per day.

Prior to Wallops' receiving the calibration data, the GFO ground data processing system routinely performs the following: (1) adds a large constant bias to the CAL-1 range, such that the magnitude of the resultant range sum is comparable to a nominal nadir altimeter range to the surface of the earth, and then (2) applies an oscillator drift correction to the total range.

To reconstruct a meaningful CAL-1 range, Wallops performs the following: (1) using the GFO-Project-provided VTCW (Vehicle Time Code Word), removes the oscillator drift correction, and then (2) removes a large constant bias.

2.1.1 Range

The CAL-1 range calibrations are shown in the middle of Figure 2-1, denoted by the pluses and are referenced to the left vertical scale in millimeters. The data plotted nearer the bottom of the figure, denoted by the diamonds, are the Composite Temperature corresponding to the times of the calibrations; the temperatures are refer-

enced to the right vertical scale in degrees centigrade. A minor temperature dependence of approximately +0.5 mm per degree is noted, which is within the centimeter specification.

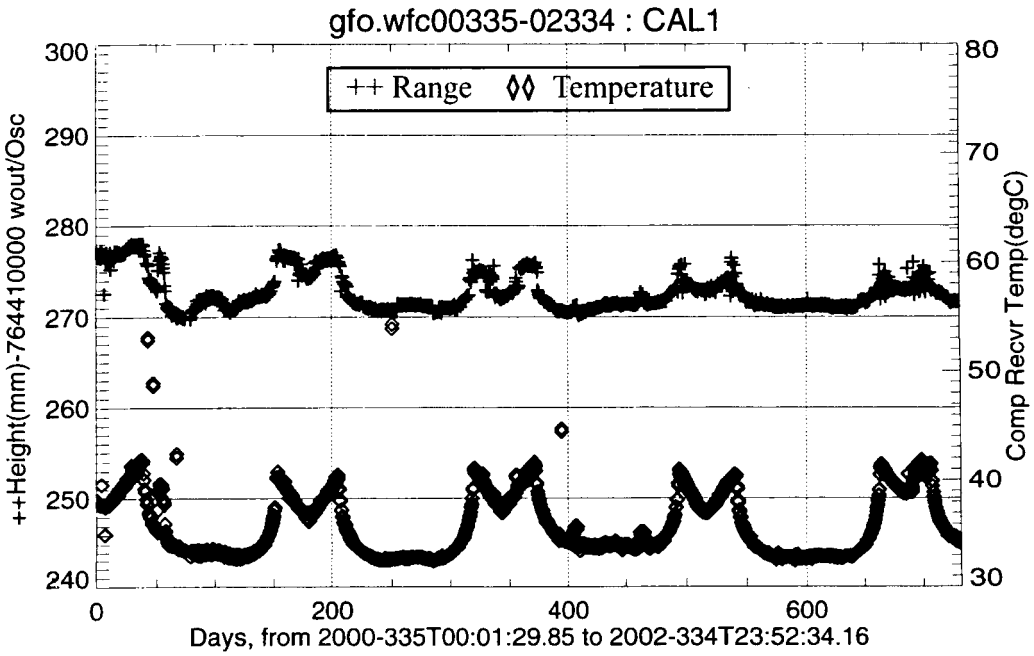

Figure 2-1 CAL-1 Range/Temperatures for the First 43 Cycles

2.1.2 AGC

The CAL-1 and CAL-2 AGCs have been routinely temperature-corrected at the GFO processing center using an algorithm derived by Wallops. The AGC temperature correction algorithms are the same for both CAL-1 and CAL-2, and were based on the initial CAL-1 results.

During the first 43 cycles, the CAL-1 AGCs remained in a fairly narrow band of 42.6+0.01 dB. No significant AGC drift is noted, and no further temperature dependency is indicated. The CAL-1 AGC is shown in Figure 2-2.

A CAL-2 AGC temperature dependence is evident in Figure 2-3 "CAL-2 AGC for the First 43 Cycles" on page 2-3. The CAL-2 shows variations, but these are correctable with temperature as can be seen by the temperature plot in Figure 2-1. WFF elected to apply the temperature correction for CAL-1 and not CAL-2 as best for normal AGC processing.

2.2 GFO Cycle (17-day) Summaries

Another indication of the GFO altimeter's internal consistency is the agreement of cycle-to-cycle means for: global significant waveheights, sigma-naughts, and windspeed. For this analysis, the measurements for complete cycles (17 days) were

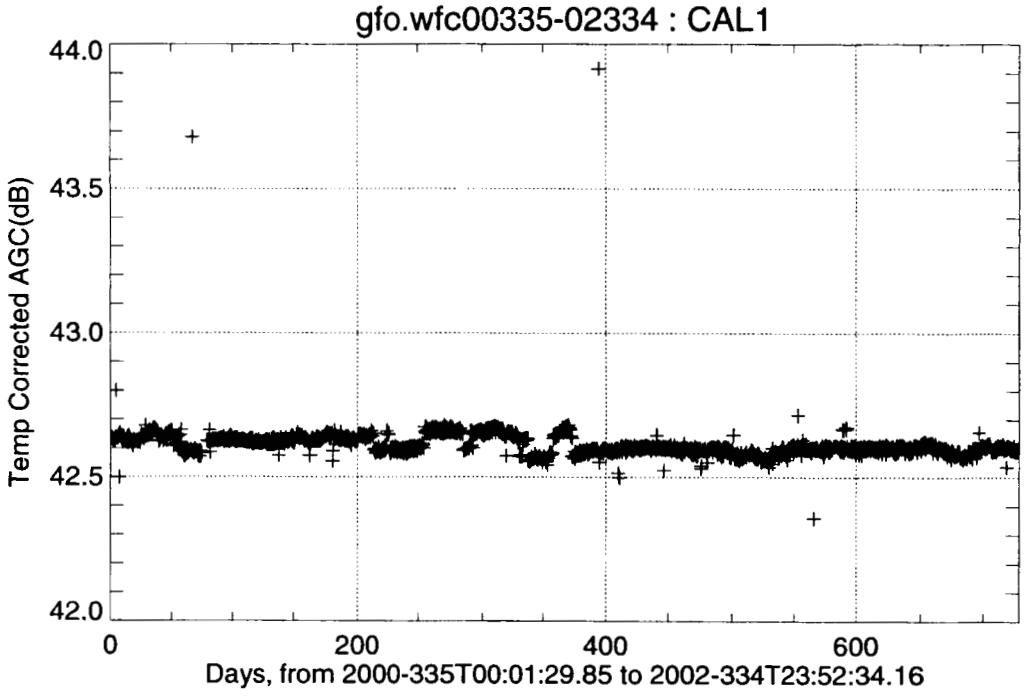

Figure 2-2 CAL-1 AGC for the First 43 Cycles

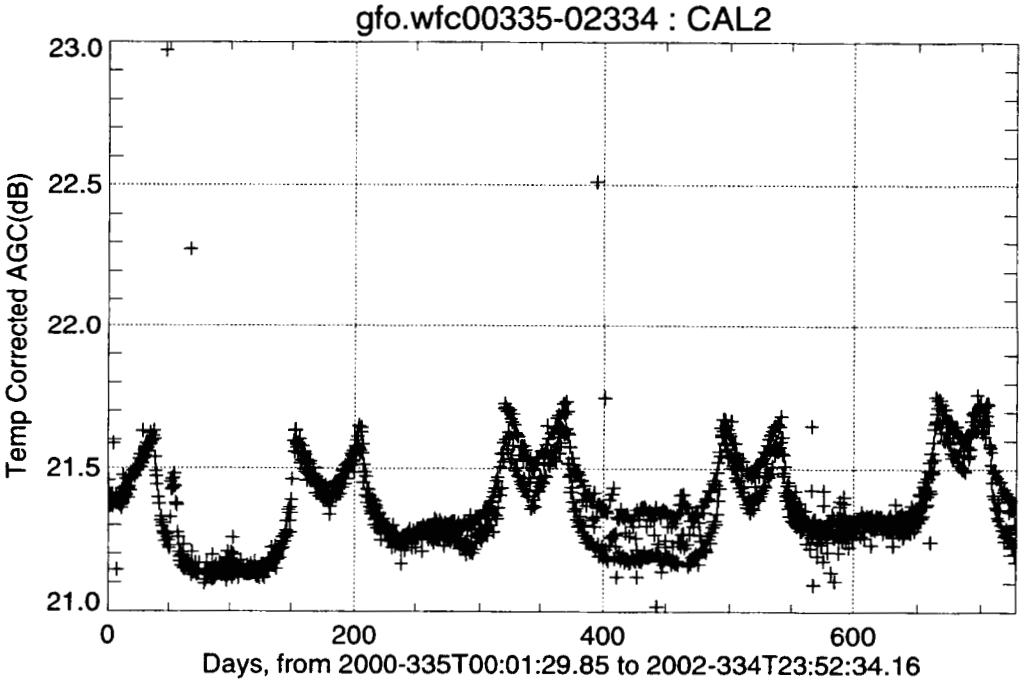

Figure 2-3 CAL-2 AGC for the First 43 Cycles

meaned, standard deviations were computed, and measurement histograms were produced.

Prior to the computations, the data sets were edited to eliminate suspect measurements. Our edit criteria are as follows:

- Quality Word #1
  - Bit 2: Record is zero-filled
  - Bit 3: Altimeter not in Fine Track
  - Bit 5: Receiver Temperature error
  - Bit 7: No smoothed VATT
  - Bit 10: SWH bounds error
  - Bit 18: Off-Nadir error
  - Bit 19: SWH standard error
  - Bits 22-31: More than 5 frames missing
- Quality Word #2
  - Bit 11: Land contamination
- Default fill values indicative of bad data

Note: Bit 0 is defined as LSB

We suggest the use of above criteria by data users for editing the GFO data.

The process by which the cycle summaries were produced involved the following criteria:

- 60 second averaging interval
- $0.2 < SWH < 12.0$
- $-66.0 < Latitude < 66.0$
- $6.0 < Sigma0 < 16.0$
- $44 <$ Numpoints in intervals < 62

Table 2-1 Column Definitions for Table 2-2 Cycle Summaries

Cycle	Equivalent to Exactly 17 Days
Days in Cycles	Beginning Year and Julian Day through the Ending Year and Julian Day of the Cycle
SSHUSTD (m)	Cycle Average Uncorrected Sea Surface Height Standard Deviation
SWH (m)	Cycle Average Significant Wave Height
Sigma0 (dB)	Cycle Average Sigma0
AGC (dB)	Cycle Average Automatic Gain Control
Attitude (deg)	Cycle Average Attitude
RecvrTemp (C)	Cycle Average Receiver Temperature
WindSpeed (.1m/s)	Cycle Average Wind Speed
# Points Used	Total Number of Points Processed in the Cycle Period used in the Cycle Average

All the cycle summaries produced at Wallops so far indicate excellent cycle-to-cycle consistency. Summaries for the first 43 cycles (cycles numbered 0-42) are shown in Table 2-2 "Cycle Summaries".

Table 2-2 Cycle Summaries

Cycle	Days in Cycle, yyddd	SSHUSTD, m	SWH, m	Sigma0, dB	AGC, dB	Attitude, deg	RecvrTemp, C	WindSpeed, 0.1m/s	# Points Used
0	00335 - 00351	0.0426	2.4634	11.3467	43.2169	0.2392	38.1004	82.2133	661930.0
1	00352 - 01002	0.0435	2.5893	11.5076	43.3676	0.2502	39.7169	76.9435	670179.0
2	01003 - 01019	0.0421	2.4539	11.5464	43.4072	0.2422	38.1625	76.1032	705661.0
3	01020 - 01036	0.0424	2.5145	11.3383	43.2053	0.2105	35.9461	82.4006	705066.0
4	01037 - 01053	0.0428	2.5048	11.2909	43.1539	0.2340	33.6365	83.9581	575112.0
5	01054 - 01070	0.0440	2.5950	11.3143	43.1754	0.2362	33.5342	83.6164	792452.0
6	01071 - 01087	0.0443	2.6296	11.3496	43.2111	0.2335	33.3062	82.7288	778777.0
7	01088 - 01104	0.0448	2.6688	11.2597	43.1205	0.2255	33.2810	85.4292	727955.0
8	01105 - 01121	0.0442	2.6110	11.3374	43.1974	0.2270	35.3536	82.6415	781960.0
9	01122 - 01138	0.0445	2.5979	11.5202	43.3821	0.2361	38.7920	77.0297	682787.0
10	01139 - 01155	0.0429	2.4273	11.5259	43.3883	0.2254	37.1360	77.1754	769511.0
11	01156 - 01172	0.0431	2.4743	11.5309	43.3925	0.2301	38.9564	77.0553	761652.0
12	01173 - 01189	0.0442	2.6248	11.3143	43.1751	0.2200	36.1441	83.6154	767214.0
13	01190 - 01206	0.0437	2.5423	11.3137	43.1745	0.2083	33.2537	81.3067	750630.0
14	01207 - 01223	0.0441	2.6452	11.1944	43.0576	0.2097	32.7243	87.3751	747226.0
15	01224 - 01240	0.0428	2.5422	11.2748	43.1381	0.2180	32.9023	84.7361	757575.0

Table 2-2 Cycle Summaries (Continued)

Cycle	Days in Cycle, yyddd	SSHUSTD, m	SWH, m	Sigma0, dB	AGC, dB	Attitude, deg	RecvrTemp, C	WindSpeed, 0.1m/s	# Points Used
16	01241 - 01257	0.0440	2.5988	11.2864	43.1472	0.2232	32.8176	84.7772	752352.0
17	01258 - 01274	0.0441	2.5846	11.3227	43.1835	0.2298	33.1715	83.4550	708963.0
18	01275 - 01291	0.0442	2.6115	11.4142	43.2758	0.2441	36.5931	80.1253	733146.0
19	01292 - 01308	0.0422	2.3769	11.5406	43.4015	0.2506	39.0869	76.0492	740202.0
20	01309 - 01325	0.0431	2.4908	11.3894	43.2502	0.2456	38.0352	80.7366	763436.0
21	01326 - 01342	0.0423	2.4054	11.5086	43.3702	0.2565	40.3354	76.7640	760609.0
22	01343 - 01359	0.0421	2.4211	11.3740	43.2340	0.2390	36.0733	81.4164	776570.0
23	01360 - 02011	0.0430	2.4595	11.3632	43.2214	0.2372	34.6067	81.6712	777658.0
24	02012 - 02028	0.0419	2.4555	11.2929	43.1544	0.2374	33.8748	83.8318	788337.0
25	02029 - 02045	0.0434	2.5995	11.2344	43.0959	0.2403	33.9140	85.6793	793967.0
26	02046 - 02062	0.0418	2.4363	11.3118	43.1726	0.1960	33.7699	83.3240	776874.0
27	02063 - 02079	0.0420	2.4820	11.2993	43.1601	0.0959	34.0986	83.7140	759495.0
28	02080 - 02096	0.0431	2.5973	11.3047	43.1647	0.1062	35.5185	83.6089	763915.0
29	02097 - 02113	0.0429	2.5122	11.4835	43.3435	0.1303	39.3145	78.3730	777198.0
30	02114 - 02130	0.0433	2.5705	11.3721	43.2352	0.1275	37.5810	81.2207	771475.0
31	02131 - 02147	0.0431	2.5229	11.5137	43.3769	0.1378	39.4172	77.3539	769096.0
32	02148 - 02164	0.0426	2.4842	11.3335	43.1951	0.1176	34.9234	82.7158	751307.0
33	02165 - 02181	0.0432	2.5975	11.1661	43.0261	0.0936	33.2024	88.1230	695887.0
34	02182 - 02198	0.0426	2.4700	11.2788	43.1397	0.0891	32.8489	84.6981	759199.0
35	02199 - 02215	0.0436	2.6013	11.2309	43.0918	0.0856	32.9862	86.5075	753679.0
36	02216 - 02232	0.0437	2.5655	11.2559	43.1159	0.0816	32.9686	85.8057	756166.0
37	02233 - 02249	0.0432	2.4940	11.3231	43.1839	0.0824	33.1290	83.5694	750831.0
38	02250 - 02266	0.0433	2.4764	11.4104	43.2782	0.0984	35.2167	80.6096	722417.0
39	02267 - 02283	0.0417	2.3496	11.5440	43.4040	0.1257	39.8588	75.9570	790561.0
40	02284 - 02300	0.0429	2.4216	11.5900	43.4525	0.1260	39.4430	74.9548	741718.0
41	02301 - 02317	0.0452	2.4552	11.4899	43.3531	0.1291	39.5481	77.9058	758725.0
42	02318 - 02334	0.0366	2.4707	11.3157	43.1773	0.1060	34.9509	83.2591	726926.0

2.2.1 Sigma0

The Sigma0 cycle-averages are plotted in Figure 2-4. Sigma0 has remained in a band between 11.2 and 11.6 dB.

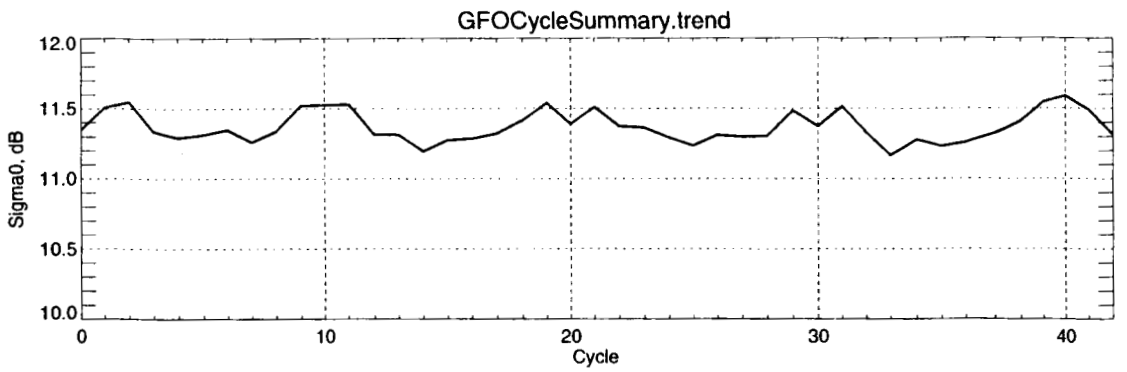

Figure 2-4 Cycle-Averages Sigma0 in dB

2.2.2 Significant Wave Height

The significant wave height (SWH) cycles-averages are shown in Figure 2-5. SWH has remained between 2.3 and 2.7 meters.

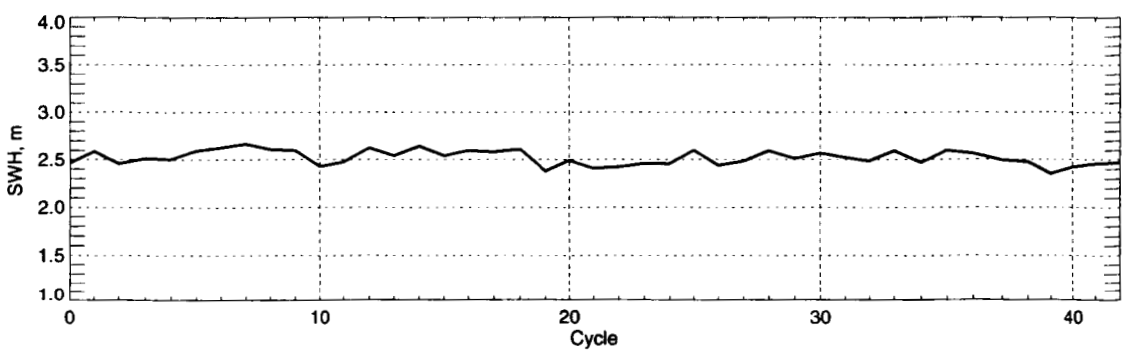

Figure 2-5 Cycle-Averages Significant Wave Height in Meters

2.2.3 Attitude

The attitude (Off-Nadir) cycle-averages are shown in Figure 2-6. Through Cycle 25, the attitude remained between 0.20 and 0.25 degrees. On day 2002057, a spacecraft attitude adjustment lowered the cycle-average attitude by approximately 0.10 degree.

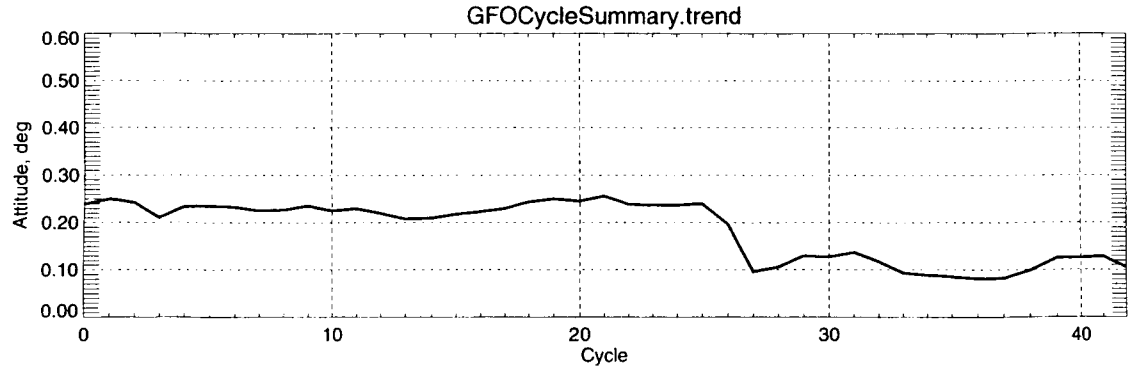

Figure 2-6 Cycle-Averages Attitude in Degrees

2.2.4 Receiver Temperature

The receiver temperature cycle-averages are shown in Figure 2-7. Receiver temperature has remained between 33.0 and 40.0 Celsius Degrees.

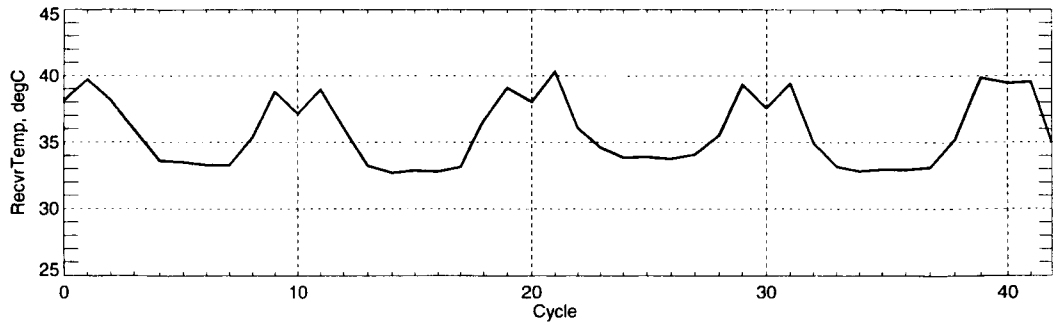

Figure 2-7 Cycle-Averages Receiver Temperature in Celsius Degrees

2.2.5 Windspeed

The windspeed cycle-averages are shown in Figure 2-8. Windspeed has remained between 7.5 and 8.8 meters/second.

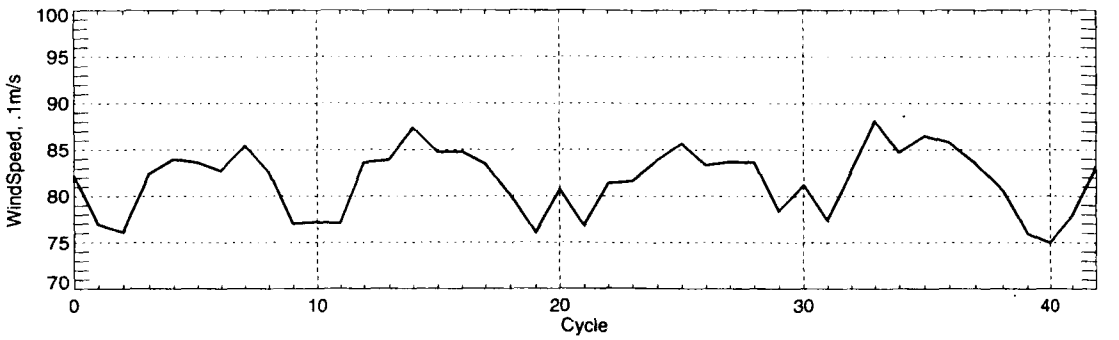

Figure 2-8 Cycle-Averages Windspeed in Meters Per Second

2.2.6 Windspeed Dependence on Receiver Temperature

As we have noted in the past, the GFO Sigma0 has an uncorrected small instrument temperature dependence of about +/-0.2 dB. This is seen in Figure 2-10 that shows global Sigma0 vs. receiver temperature. Since this variation is less than the GFO specification, the correction was not implemented.

The propagation of the unmodeled Sigma0 temperature-dependence to windspeed can be seen in the global average windspeed shown in Figure 2-8 when compared to the receiver temperature in Figure 2-7. The relationship is plotted in Figure 2-11 showing a total cycle-average range of about +/-0.6 meters/second. This is well within the GFO windspeed specification of 2.0 meters/second. Figure 2-9 shows the resulting global cycle average windspeed after being corrected, at our calculated rate of –0.117 m/s per degree, for the receiver temperature.

The importance of this figure is that it clearly shows that the GFO altimeter's power-related components remain calibrated and are very stable over the entire 43 cycles. There are no signs of power degrading in the transmitter or receiver sections.

2.2.7 Sigma0 vs. Receiver Temperature

In Figure 2-10, there is an apparent small Sigma0 dependence on temperature, similar in magnitude to the CAL-2 dependence on temperature mentioned in Section 2.1.2.

2.2.8 Windspeed vs. Receiver Temperature

In Figure 2-11, there is an apparent windspeed dependence on temperature.

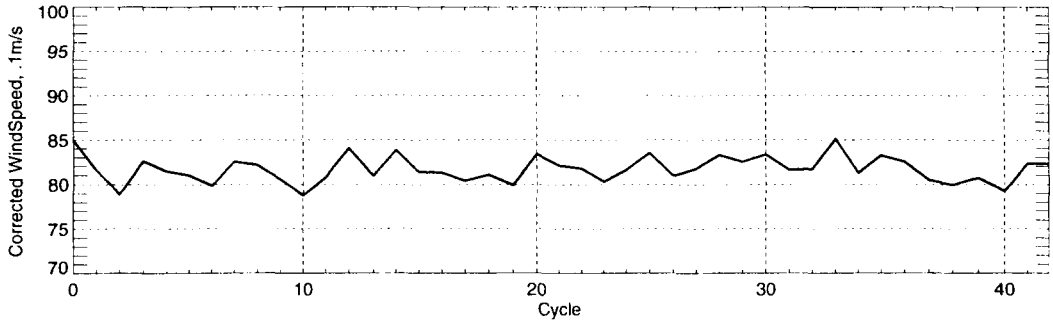

Figure 2-9 Cycle-Averages Corrected Windspeed in Meters Per Second

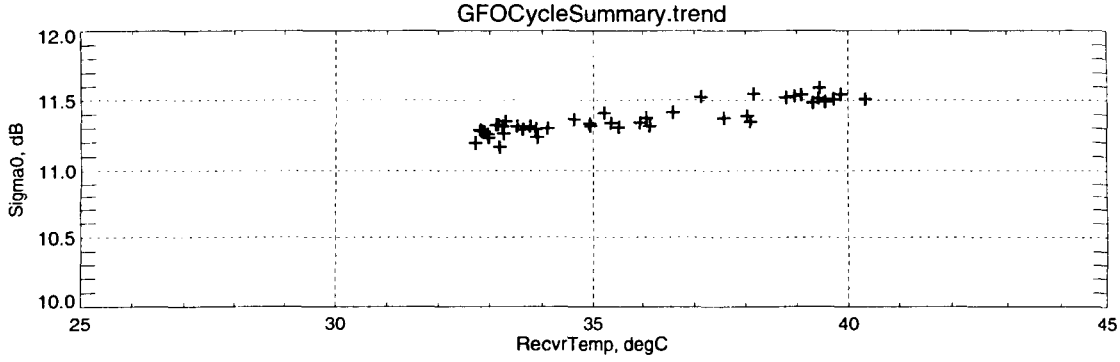

Figure 2-10 Cycle-Averages Sigma0 vs. Temperature

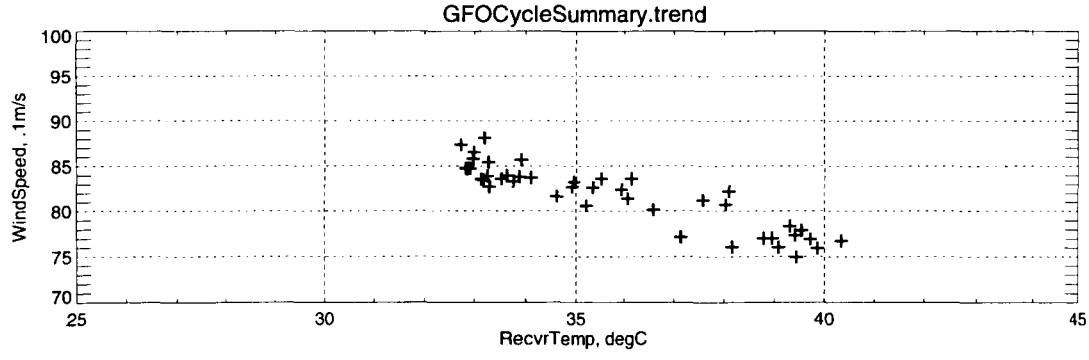

Figure 2-11 Cycle Averages Windspeed vs. Temperature

2.2.9 Cycle Summary Conclusions

We have previously found with TOPEX that, if the geophysical data are strictly edited, a global cycle average of parameters provides a means of assessing cycle-to-cycle stability, and that variations can indicate changes in the altimeter instrument. The GFO cycle summary, Table 2-1, shows consistent values for the key parameters.

The GFO Sigma0, Figure 2-4, as expected exhibits a small variation with SWH, Figure 2-5, reflecting seasonal changes. We have not applied a seasonal correction to the data, but this raw Sigma0 still remains within 0.5 dB that is well within the 1 dB specification.

The waveform estimated attitude (Off-Nadir), Figure 2-6, has remained stable except for the spacecraft attitude adjustment on 2002 day 057. This indicates that the data are consistent, and that the waveform samples have not changed their calibrations.

The windspeed, Figure 2-8, is directly related to the Sigma0 and shows approximately a 1.3 meter per second variation. For calibration purposes, one could remove the seasonal variation, and further could provide a temperature correction, but again the raw average is better than the specification of 2 meters per second.

There is a minor temperature effect on Sigma0 as shown in Figure 2-10. This can also be seen by comparing Figure 2-4 and Figure 2-8 which account for most of the Sigma0 variations.

2.3 GFO Key Events Log

The key events log is a complete list of sensor-related events. The key events for the GFO altimeter since acceptance are summarized in Table 2-3. These sensor-related key events are extracted from:

http://gfo.bmpcoe.org/Gfo/Event_Log/gfo_event_log.htm.

Additionally, key events from a Wallops perspective have been included. Highlighted entries from 26 November 2001 to 27 November 2002 are the events that have occurred since the previous Engineering Assessment Report.

Table 2-3 GFO Key Events Log

Event	Date & Time of Event	Comments
Acceptance	29 Nov 2000 2000334T00:00:00Z	GFO Acceptance. SPAWAR authorizes DD250s.
Trim Burn	04 Dec 2000 2000339T06:55:00Z	ERO Trim Burn. 33.8 mm/sec at 0 deg yaw. Purpose is to raise the SMA and maintain the ERO.

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Commanded	06 Dec 2000 2000341T13:34:00Z	A ground system planning error resulted in data outage of about 10.5 hours. The last command in the sequence, for an RA Calibration via CSM was omitted. This command normally sends the RA back to the Track mode. Since this last command was not sent, the RA was left in Standby mode until the next Calibration sequence was executed. Returned to track 06 Dec 2000, 2000341T23:59:00Z.
Moon Intrusion	07 Dec 2000 2000342T11:46:25Z	Moon Intrusion affected GFO pointing. Intrusion resulted in the nadir error exceeding acceptable limits (.27 degrees).
Moon Intrusion	07 Dec 2000 2000342T13:27:10Z	Moon Intrusion affected GFO pointing. Intrusion resulted in the nadir error exceeding acceptable limits (.27 degrees).
Moon Intrusion	07 Dec 2000 2000342T15:07:40Z	Moon Intrusion affected GFO pointing. Intrusion resulted in the nadir error exceeding acceptable limits (.27 degrees).
Trim Burn	08 Dec 2000 2000343T02:19:00Z	ERO Trim Burn. 6.9 mm/sec at 180 deg yaw (-6.9 mm/s). Purpose is to lower the SMA and keep the ground track from exceeding the western limit of the ERO.
Moon Intrusion	14 Dec 2000 2000349T12:48:53Z	Moon Intrusion affected GFO pointing.
Moon Intrusion	14 Dec 2000 2000349T14:48:34Z	Moon Intrusion affected GFO pointing.
Trim Burn	28 Dec 2000 2000363T12:53:00Z	ERO Trim Burn. 27.011 mm/sec at 0 deg yaw. Purpose is to raise the SMA and keep the ground track from exceeding the eastern limit of the ERO.
Moon Intrusion	14 Jan 2001 2001014T05:06:00Z	The maximum pointing error (ADNADER) was 0.55 degrees.Other intrusions at around this time may have occurred. None exceeded 0.27 degrees.
Commanded	19 Jan 2001 2001019T18:02:00Z	The attitude changed from above.25 to below.20 degrees and the Receiver Temperature started to increase from 35 degrees. Explanation: Navsoc started the battery reconditioning sequence. Among other things, this sequence turns on the second horizon scanner, which would explain the improved pointing. In addition to the horizon scanner, a GPS Receiver and the catbed heaters are also turned on - this would explain the increase in Temperatures. Battery deep discharge reconditioning was initiated on Jan 19 at 18:02z.
Behavior	20 Jan 2001 2001020T15:28:00Z	"Anomalous behavior in GFO reaction wheel 3 torques". Wheel torque for wheel 3 displaying unusually large swings in the applied wheel torque. Does not appear to be affecting the satellite pointing.
Variations	21 Jan 2001 2001021T00:00:00Z	Doppler problem (noise/degraded orbits). The Doppler Beacon Signal is rather noisy.

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Commanded	24 Jan 2001 2001024T03:13:00Z	"GFO reaction wheel 3". Commanded spacecraft to run with horizon scanner 2 instead of the 2 horizon scanner configuration. During the horizon scanner switch there were transient nadir pointing errors in the order of 0.58 degrees. The attitude returned back to above.25 from below.20 degrees at this time. The Receiver Temperature did not change.
Power Cycled	24 Jan 2001 2001024T23:57:42Z	Reaction wheel 3 was power cycled. No change was seen in the satellites behavior.
Commanded	25 Jan 2001 2001025T18:10:00Z	Extra Loads used for battery deep discharge conditioning were shed. This should return the satellite to normal power and thermal balance. The satellite is being kept in the 1 failed cell configuration at VT 7.5.
Variations	26 Jan 2001 2001026T00:00:00Z	Doppler problem (noise/degraded orbits). The Doppler Beacon Signal noise has subsided and tracks are good/improving. The oscillator on beacon 1 can not handle increased temperature adequately.
Commanded	26 Jan 2001 2001026T17:39:54Z	Switched to the redundant wheel (wheel 4) and disabled wheel 3. This involves putting the satellite into acquire sun and the radar altimeter in stand-by. Running on redundant wheel, in point state and the radar altimeter back in track.
Maneuver	30 Jan 2001 2001030T01:47:00Z	The magnitude will be 29.4 mm/s and the yaw will be 0 degrees. GFO has drifted out of the ERO and is currently about 1.3 km east of the centerline (300 m out of limits). After the maneuver, GFO should drift back into the ERO by 1/31 at 16:15Z. Satellite had drifted 300 m out of ERO.
Moon Intrusion	05 Feb 2001 2001036T12:31:35Z	GFO horizon scanner has experienced a moon intrusion event which has caused excursions from acceptable nadir pointing limits (.27 degrees). The time of this excursion and maximum amplitude is: 12:31:35 - 12:31:45Z (0.40 degrees max)
Moon Intrusion	05 Feb 2001 2001036T14:12:00Z	The time of this excursion and maximum amplitude is: 14:12:00 - 14:12:30Z (0.95 degrees max)
Moon Intrusion	05 Feb 2001 2001036T15:52:50Z	The time of this excursion and maximum amplitude is: 15:52:50 - 15:53:10Z (0.47 degrees max)
Moon Intrusion	10 Feb 2001 2001041T06:30:00Z	The time of the excursion and maximum amplitude is: 06:30:00 - 06:30:15Z (0.43 degrees max)
Moon Intrusion	10 Feb 2001 2001041T08:10:50Z	The time of the excursion and maximum amplitude is: 08:10:50 - 08:11:20Z (0.86 degrees max)
Moon Intrusion	10 Feb 2001 2001041T09:51:45Z	The time of the excursion and maximum amplitude is: 09:51:45 - 09:52:10Z (0.87 degrees max)
Moon Intrusion	11 Feb 2001 2001042T04:32:25Z	The time of the excursion and maximum amplitude is: 04:32:25 - 04:32:40Z (0.35 degrees max)

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Moon Intrusion	11 Feb 2001 2001042T13:47:05Z	The time of the excursion and maximum amplitude is: 13:47:05 - 13:47:10Z (0.60 degrees max)
Under Voltage	12 Feb 2001 2001043T21:57:00Z	GFO apparently suffered an under-voltage (UV1) event. As a consequence, the payload bus was powered off. Due to the load shedding effect of the UV1, GFO is in a safe power configuration. The payloads are off and GFO is not collecting data.
Payloads On	15 Feb 2001 2001045T06:49:00Z	Payloads turned back on. GFO in standby mode.
In Operation	16 Feb 2001 2001047T19:00:00Z	GFO collecting data, payloads switched from standby mode to track mode. The reconditioning reset, the battery voltages, temperatures and pressures appeared normal. The payloads were turned back on, software patches installed and then set to track and produce data over the weekend to test the batteries under load. Examination of the battery and other satellite data yesterday and today indicates that the bus voltages is about 27.8 (28 volt bus), the NiH battery temperatures are in the normal range of 8 to 9 deg C, and the pressures are running between 495 and 620 psi as they should. The system will be left in this condition (VT is 6.0) and closely monitored.
Trim Maneuver	01 Mar 2001 2001060T23:06:00Z	The purpose of the maneuver will be to raise the semi-major axis and maintain the ERO. The burn magnitude will be 28.719 mm/sec with a zero degree yaw offset.
Moon Intrusion	06 Mar 2001 2001065T00:54:00Z	The time of the excursion and maximum amplitude is: 00:54:00Z - 00:54:20Z (0.34 degrees max)
Moon Intrusion	06 Mar 2001 2001065T02:34:10Z	The time of the excursion and maximum amplitude is: 02:34:10Z - 02:34:40Z (0.39 degrees max)
Moon Intrusion	06 Mar 2001 2001065T04:14:35Z	The time of the excursion and maximum amplitude is: 04:14:35Z - 04:15:10Z (0.48 degrees max)
Moon Intrusion	06 Mar 2001 2001065T05:54:55Z	The time of the excursion and maximum amplitude is: 05:54:55Z - 05:55:05Z (0.40 degrees max)
Moon Intrusion	06 Mar 2001 2001065T19:52:45Z	The time of the excursion and maximum amplitude is: 19:52:45Z - 19:53:15Z (0.63 degrees max)
Moon Intrusion	12 Mar 2001 2001071T04:12:30Z	The time of the excursion and maximum amplitude is: 04:12:30Z - 04:12:45Z (0.49 degrees max)
Moon Intrusion	12 Mar 2001 2001071T05:52:35Z	The time of the excursion and maximum amplitude is: 05:52:35Z - 05:53:10Z (0.67 degrees max)
Moon Intrusion	12 Mar 2001 2001071T07:33:05Z	The time of the excursion and maximum amplitude is: 07:33:05Z - 07:33:40Z (0.86 degrees max)
Moon Intrusion	12 Mar 2001 2001071T09:13:40Z	The time of the excursion and maximum amplitude is: 09:13:40Z - 09:14:05Z (0.74 degrees max)

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Moon Intrusion	12 Mar 2001 2001071T18:10:20Z	The time of the excursion and maximum amplitude is: 18:10:20Z - 18:10:40Z (0.41 degrees max)
Moon Intrusion	12 Mar 2001 2001071T19:50:43Z	The time of the excursion and maximum amplitude is: 19:50:43Z - 19:51:10Z (0.59 degrees max)
Test Support	14 Mar 2001 2001073T21:48:30Z	Due to a Momentum Wheel 3 Testing support, the satellite yaw was about 0.47 degrees. GFO experienced pointing errors that exceeded the.27 degrees limit. The time of the excursion is: 21:48:30Z - 21:53:00Z
Trim Maneuver	21 Mar 2001 2001080T00:55:00Z	The burn magnitude will be 30.4 mm/sec with a zero degree yaw offset.
Trim Maneuver	30 Mar 2001 2001089T01:13:00Z	The burn magnitude will be 36 mm/sec with a zero degree yaw offset.
Trim Maneuver	03 Apr 2001 2001093T00:51:00Z	The next burn will be in 100 minutes.
Trim Maneuver	03 Apr 2001 2001093T02:31:00Z	The total burn magnitude will be 70 mm/sec with a zero degree yaw offset.
Trim Maneuver	04 Apr 2001 2001094T03:22:00Z	The burn magnitude will be 40 mm/sec with a 180 degree yaw offset.
Moon Intrusion	10 Apr 2001 2001100T19:53:33Z	The time of the excursion and maximum amplitude is: 19:53:33Z - 19:53:45Z (0.33 degrees max)
Moon Intrusion	10 Apr 2001 2001100T21:33:50Z	The time of the excursion and maximum amplitude is: 21:33:50Z - 21:34:40Z (0.59 degrees max)
Moon Intrusion	10 Apr 2001 2001100T22:38:13Z	The time of the excursion and maximum amplitude is: 22:38:13Z - 22:38:48Z (0.40 degrees max)
Moon Intrusion	10 Apr 2001 2001100T23:14:35Z	The time of the excursion and maximum amplitude is: 23:14:35Z - 23:15:03Z (0.72 degrees max)
Moon Intrusion	11 Apr 2001 2001101T00:18:45Z	The time of the excursion and maximum amplitude is: 00:18:45Z - 00:19:20Z (0.68 degrees max)
Moon Intrusion	11 Apr 2001 2001101T00:55:02Z	The time of the excursion and maximum amplitude is: 00:55:02Z - 00:55:07Z (0.31 degrees max)
Moon Intrusion	11 Apr 2001 2001101T01:59:20Z	The time of the excursion and maximum amplitude is: 01:59:20Z - 01:59:47Z (0.74 degrees max)
Trim Maneuver	13 Apr 2001 2001103T00:30:00Z	The burn magnitude will be 30 mm/sec with a 0 degree yaw offset.

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
CSM Upload	30 Apr 2001 2001120T00:00:00Z	CSM Time Tag Anomaly. A CSM upload was planned on Wednesday (Day 115) to be uploaded on Friday (Day 117) with commands for Monday and Tuesday (Days 120 and 121). The times in the ASCII CSM.dat file are correct. The ground system uses the SCC on the ground system at HQ to convert the times to VTCW when building the CSM command. All of the commands in that CSM were 3 days 3 hours and 40 minutes earlier than they should have been. The commands for Day 121 executed on Day 118. The commands for Day 120 were changed to Day 116 which was in the past, so GFO interpreted that as 6 days and 8.7 hours in the future from Day 116 or Day 123-124. (CSM commands can be uploaded a maximum of 6 days 8.7 hours before they execute.)
Trim Maneuver	02 May 2001 2001122T05:39:00Z	The burn magnitude will be 30.9 mm/sec with a 0 degree yaw offset. GFO out of point: 122T05:32:00Z - 122T05:44:00Z.
Trim Maneuver	08 May 2001 2001128T05:05:00Z	The purpose of the maneuver will be a small "stopping" maneuver. The burn magnitude will be 4.4 mm/sec with a 180 degree yaw offset. GFO out of point: 128T04:58:00Z - 128T05:10:00Z.
Trim Maneuver	31 May 2001 2001151T23:49:00Z	The burn magnitude will be 16.8 mm/sec with a 0 degree yaw offset. GFO out of point: 151T23:42:00Z - 151T23:54:00Z
Reconditioning	04 Jun 2001 2001155T00:00:00Z	Battery reconditioning. This will continue until 14 June. Expected to have no affect on normal operations.
Moon Intrusion	11 Jun 2001 2001162T01:00:27Z	The time of the excursion and maximum amplitude is: 01:00:27Z - 01:00:29Z (0.31 degrees max)
Moon Intrusion	11 Jun 2001 2001162T02:41:02Z	The time of the excursion and maximum amplitude is: 02:41:02Z - 02:41:25Z (0.63 degrees max)
Moon Intrusion	11 Jun 2001 2001162T04:21:42Z	The time of the excursion and maximum amplitude is: 04:21:42Z - 04:21:50Z (0.52 degrees max)
Antenna Swap	20 Jun 2001 2001171T00:00:00Z	The doppler system antenna at Headquarter has been swapped yesterday (6/20) afternoon (Pacific Time). As a result, the doppler system is out of degraded mode, and working nominally.
Antenna Swap	28 Jun 2001 2001179T00:00:00Z	The doppler system antenna at Headquarter is now back up and functioning again.
Trim Maneuver	29 Jun 2001 2001180T00:03:00Z	The burn magnitude will be 14.6 mm/sec with a 0 degree yaw offset. GFO out of point: 179T23:56:00Z - 180T00:08:00Z
Moon Intrusion	02 Jul 2001 2001183T02:48:53Z	The time of the excursion and maximum amplitude is: 02:48:53Z - 02:49:00Z (0.28 degrees max)
Moon Intrusion	02 Jul 2001 2001183T04:29:37Z	The time of the excursion and maximum amplitude is: 04:29:37Z - 04:29:42Z (0.29 degrees max)

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Moon Intrusion	02 Jul 2001 2001183T17:29:02Z	The time of the excursion and maximum amplitude is: 17:19:02Z - 17:19:33Z (1.07 degrees max)
Moon Intrusion	02 Jul 2001 2001183T18:59:45Z	The time of the excursion and maximum amplitude is: 18:59:45Z - 19:00:15Z (0.92 degrees max)
Moon Intrusion	02 Jul 2001 2001183T20:40:23Z	The time of the excursion and maximum amplitude is: 20:40:23Z - 20:40:55Z (0.95 degrees max)
Moon Intrusion	02 Jul 2001 2001183T22:20:52Z	The time of the excursion and maximum amplitude is: 22:20:52Z - 22:20:58Z (0.34 degrees max)
Moon Intrusion	31 Jul 2001 2001212T07:55:22Z	The time of the excursion and maximum amplitude is: 07:55:22Z - 07:55:25Z (0.31 degrees max)
Moon Intrusion	01 Aug 2001 2001213T10:08:07Z	The time of the excursion and maximum amplitude is: 10:08:07Z - 10:08:30Z (0.94 degrees max)
Moon Intrusion	01 Aug 2001 2001213T11:48:34Z	The time of the excursion and maximum amplitude is: 11:48:34Z - 11:49:03Z (0.98 degrees max)
Moon Intrusion	01 Aug 2001 2001213T13:28:59Z	The time of the excursion and maximum amplitude is: 13:28:59Z - 13:29:36Z (0.51 degrees max)
Moon Intrusion	01 Aug 2001 2001213T15:09:59Z	The time of the excursion and maximum amplitude is: 15:09:59Z - 15:10:12Z (0.61 degrees max)
Moon Intrusion	07 Aug 2001 2001219T16:59:40Z	The time of the excursion and maximum amplitude is: 16:59:40Z - 16:59:55Z (0.28 degrees max)
Moon Intrusion	07 Aug 2001 2001219T18:39:27Z	The time of the excursion and maximum amplitude is: 18:39:27Z - 18:39:48Z (0.90 degrees max)
Moon Intrusion	07 Aug 2001 2001219T20:20:17Z	The time of the excursion and maximum amplitude is: 20:20:17Z - 20:20:45Z (0.81 degrees max)
Moon Intrusion	07 Aug 2001 2001219T22:00:58Z	The time of the excursion and maximum amplitude is: 22:00:58Z - 22:01:03Z (0.29 degrees max)
Moon Intrusion	08 Aug 2001 2001220T23:28:25Z	The time of the excursion and maximum amplitude is: 23:28:25Z - 23:28:33Z (0.29 degrees max)
Trim Maneuver	14 Aug 2001 2001226T00:55:00Z	The burn magnitude will be 18.6 mm/sec with a 0 degree yaw offset. GFO out of point: 226T00:48:00Z - 226T01:00:00Z

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Point Test	27 Aug 2001 2001239T17:05:40Z	GFO normally uses the vector method in point mode, but this method does not allow the use of the Target Table (Table 39) to generate offsets for the upcoming ABCAL maneuvers. The quaternion method does allow the use of the Target Table, but can be susceptible to coupling between Z-axis rotation and nadir pointing errors. A test was performed on GFO today (DOY 239) to determine the amount of coupling between Z-axis rotation and nadir errors while in quaternion point mode. GFO was placed in quaternion point mode for one rev (239/17:05:40 through 239/18:45:34) in order to collect the necessary data, then switched back into vector point mode.
Trim Maneuver	31 Aug 2001 2001243T00:27:00Z	The burn magnitude will be 23.6 mm/sec with a 0 degree yaw offset. GFO out of point: 243T00:20:00Z - 243T00:32:00Z
Moon Intrusion	07 Sep 2001 2001250T04:06:15Z	The time of the excursion and maximum amplitude is: 04:06:15Z - 04:06:40Z (0.39 degrees max)
Moon Intrusion	07 Sep 2001 2001250T05:46:45Z	The time of the excursion and maximum amplitude is: 05:46:45Z - 05:47:13Z (0.49 degrees max)
Moon Intrusion	07 Sep 2001 2001250T07:27:02Z	The time of the excursion and maximum amplitude is: 07:27:02Z - 07:27:35Z (0.46 degrees max)
Moon Intrusion	07 Sep 2001 2001250T09:07:34Z	The time of the excursion and maximum amplitude is: 09:07:34Z - 09:08:05Z (0.67 degrees max)
Moon Intrusion	07 Sep 2001 2001250T10:48:10Z	The time of the excursion and maximum amplitude is: 10:48:10Z - 10:48:35Z (0.68 degrees max)
Moon Intrusion	07 Sep 2001 2001250T12:28:45Z	The time of the excursion and maximum amplitude is: 12:28:45Z - 12:28:50Z (0.37 degrees max)
Trim Maneuver	15 Sep 2001 2001258T02:44:00Z	The burn magnitude will be 32.0 mm/sec with a 0 degree yaw offset. GFO out of point: 258T02:37:00Z - 258T02:49:00Z
Trim Maneuver 1 of 2	28 Sep 2001 2001271T01:03:00Z	The total burn magnitude will be 48.8 mm/sec with a 0 degree yaw offset. GFO out of point: 271T00:56:00Z - 271T01:08:00Z
Trim Maneuver 2 of 2	28 Sep 2001 2001271T02:43:00Z	The total burn magnitude will be 48.8 mm/sec with a 0 degree yaw offset. GFO out of point: 271T02:36:00Z - 271T02:48:00Z
Moon Intrusion	05 Oct 2001 2001278T01:54:20Z	The time of the excursion and maximum amplitude is: 01:54:20Z - 01:55:10Z (0.83 degrees max)
Moon Intrusion	05 Oct 2001 2001278T03:35:05Z	The time of the excursion and maximum amplitude is: 03:35:05Z - 03:35:35Z (0.71 degrees max)
Moon Intrusion	06 Oct 2001 2001279T20:52:20Z	The time of the excursion and maximum amplitude is: 20:52:20Z - 20:52:30Z (0.30 degrees max)

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Moon Intrusion	06 Oct 2001 2001279T22:32:25Z	The time of the excursion and maximum amplitude is: 22:32:25Z - 22:33:00Z (0.42 degrees max)
Moon Intrusion	07 Oct 2001 2001280T00:13:05Z	The time of the excursion and maximum amplitude is: 00:13:05Z - 00:13:25Z (0.34 degrees max)
Trim Maneuver 1 of 2	11 Oct 2001 2001284T02:46:00Z	The total burn magnitude will be 42.2 mm/sec with a 0 degree yaw offset. GFO out of point: 284T02:39:00Z - 284T02:51:00Z
Trim Maneuver 2 of 2	11 Oct 2001 2001284T04:26:00Z	The total burn magnitude will be 42.2 mm/sec with a 0 degree yaw offset. GFO out of point: 284T04:19:00Z - 284T04:31:00Z
Trim Maneuver 1 of 2	23 Oct 2001 2001296T03:29:00Z	The total burn magnitude will be 46.3 mm/sec with a 0 degree yaw offset. GFO out of point: 296T03:22:00Z - 296T03:34:00Z
Trim Maneuver 2 of 2	23 Oct 2001 2001296T05:09:00Z	The total burn magnitude will be 46.3 mm/sec with a 0 degree yaw offset. GFO out of point: 296T05:02:00Z - 296T05:14:00Z
Configuration	24 Oct 2001 2001297T18:46:50Z	As a result of the Wheel 3 patch activation and configuration change performed on GFO today, the satellite radar altimeter was out of track 1 mode between the following times: 297T18:46:50Z - 297T18:53:12Z. As a result, payload data will be affected accordingly. Also, the Satellite was out of point state during the following times: 297T18:47:02Z - 297T18:51:52Z.
Moon Intrusion	27 Oct 2001 2001300T21:16:00Z	The time of the excursion and maximum amplitude is: 21:16:00Z - 21:16:10Z (0.33 degrees max).
Moon Intrusion	27 Oct 2001 2001300T22:56:35Z	The time of the excursion and maximum amplitude is: 22:56:35Z - 22:56:40Z (0.30 degrees max).
Moon Intrusion	28 Oct 2001 2001301T03:30:30Z	The time of the excursion and maximum amplitude is: 03:30:30Z - 03:30:40Z (0.33 degrees max).
Moon Intrusion	28 Oct 2001 2001301T05:11:00Z	The time of the excursion and maximum amplitude is: 05:11:00Z - 05:11:30Z (0.64 degrees max).
Moon Intrusion	28 Oct 2001 2001301T06:51:35Z	The time of the excursion and maximum amplitude is: 06:51:35Z - 06:51:50Z (0.67 degrees max).
Moon Intrusion	28 Oct 2001 2001301T08:32:10Z	The time of the excursion and maximum amplitude is: 08:32:10Z - 08:32:25Z (0.40 degrees max).
Trim Maneuver	01 Nov 2001 2001305T05:28:00Z	The burn magnitude will be 31.5 mm/sec with a 0 degree yaw offset. GFO out of point: 305T05:21:00Z - 305T05:33:00Z.
Moon Intrusion	04 Nov 2001 2001308T06:19:15Z	The time of the excursion and maximum amplitude is: 06:19:15Z - 06:19:45Z (0.65 degrees max).

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Moon Intrusion	04 Nov 2001 2001308T07:59:50Z	The time of the excursion and maximum amplitude is: 07:59:50Z - 08:00:20Z (0.63 degrees max).
Moon Intrusion	04 Nov 2001 2001308T09:40:30Z	The time of the excursion and maximum amplitude is: 09:40:30Z - 09:40:35Z (0.33 degrees max).
Moon Intrusion	05 Nov 2001 2001309T05:17:10Z	The time of the excursion and maximum amplitude is: 05:17:10Z - 05:17:20Z (0.29 degrees max).
Moon Intrusion	05 Nov 2001 2001309T06:57:50Z	The time of the excursion and maximum amplitude is: 06:57:50Z - 06:58:00Z (0.35 degrees max).
ERO Violation	06 Nov 2001 2001310T01:45:00Z	Due to a decrease in drag, the GFO ground track is going to exceed the ERO (Tuesday 11/6) for about 6.5 days. The ERO is predicted to exceed 1000 m West on 11/6 at 01:45Z. The maximum excursion of 1227 m West will be on 11/9 at 06:54Z and the ground track will re-enter the ERO on 11/12 at 17:04Z.
Configuration	07 Nov 2001 2001311T19:51:34Z	On GFO rev Det A 19549 a switch of the reaction wheel configuration from 1-2-3 to 1-2-4.
Back in ERO	08 Nov 2001 2001312T21:00:00Z	GFO's ground track has turned around. The average ground track will be back inside the 1 km limit 312T21:00.
Trim Maneuver	15 Nov 2001 2001319T01:21:00Z	The burn magnitude will be 28.2 mm/sec with a 0 degree yaw offset. GFO out of point: 319T01:14:00Z - 305T01:27:00Z.
Moon Intrusion	**26 Nov 2001 2001330T22:03:10Z**	**The time of the excursion and maximum amplitude is: 22:03:10Z - 22:03:45Z (0.67 degrees max).**
Moon Intrusion	**26 Nov 2001 2001330T23:43:50Z**	**The time of the excursion and maximum amplitude is: 23:43:50Z - 23:44:25Z (0.78 degrees max).**
Moon Intrusion	**27 Nov 2001 2001331T01:24:25Z**	**The time of the excursion and maximum amplitude is: 01:24:25Z - 01:24:40Z (0.54 degrees max).**
Moon Intrusion	**28 Nov 2001 2001332T03:07:55Z**	**The time of the excursion and maximum amplitude is: 03:07:55Z - 03:08:05Z (0.41 degrees max).**
Moon Intrusion	**28 Nov 2001 2001332T04:48:35Z**	**The time of the excursion and maximum amplitude is: 04:48:35Z - 04:49:05Z (0.51 degrees max).**
Moon Intrusion	**28 Nov 2001 2001332T06:29:15Z**	**The time of the excursion and maximum amplitude is: 06:29:15Z - 06:29:25Z (0.31 degrees max).**
Trim Maneuver	**29 Nov 2001 2001333T00:40:00Z**	**The burn magnitude will be 26.5 mm/sec with a 0 degree yaw offset. GFO out of point: 305T00:33:00Z - 305T00:46:00Z.**
Trim Maneuver	**13 Dec 2001 2001347T01:22:00Z**	**The burn magnitude will be 25.7 mm/sec with a 0 degree yaw offset. GFO out of point: 305T01:15:00Z - 305T01:28:00Z.**

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
ABCAL	20 Dec 2001 2001354T16:35:00Z	Performed ABCAL Maneuver: 354T16:35:00Z - 354T16:51:00Z. Each off-nadir excursion angle is 0.6 degrees in magnitude.
Trim Maneuver 1 of 2	26 Dec 2001 2001360T05:53:00Z	The total burn magnitude will be 39.0 mm/sec with a 0 degree yaw offset. GFO out of point: 360T05:46:00Z - 360T05:59:00Z.
Trim Maneuver 2 of 2	26 Dec 2001 2001360T07:34:00Z	The total burn magnitude will be 39.0 mm/sec with a 0 degree yaw offset. GFO out of point: 360T07:27:00Z - 360T07:40:00Z.
Moon Intrusion	27 Dec 2001 2001361T07:40:45Z	The time of the excursion and maximum amplitude is: 07:40:45Z - 07:41:30Z (0.35 degrees max).
Moon Intrusion	27 Dec 2001 2001361T09:21:50Z	The time of the excursion and maximum amplitude is: 09:21:50Z - 09:22:20Z (0.35 degrees max).
Moon Intrusion	27 Dec 2001 2001361T23:22:55Z	The time of the excursion and maximum amplitude is: 23:22:55Z - 23:23:15Z (0.33 degrees max).
Moon Intrusion	28 Dec 2001 2001362T01:03:35Z	The time of the excursion and maximum amplitude is: 01:03:35Z - 01:03:55Z (0.46 degrees max).
Trim Maneuver	03 Jan 2002 2002003T03:23:00Z	The burn magnitude will be 26.9 mm/sec with a 0 degree yaw offset. GFO out of point: 003T03:16:00Z - 003T03:29:00Z.
ERO Violation	03 Jan 2002 2002003T03:23:00Z	The GFO maneuver that executed on 1/3/02 03:23Z was designed to have the ground track turn around at 900 meters west. Post-maneuver analysis has shown that the maneuver was too large and will cause the ground track to drift to 1750 meters west before turning around. The ground track is predicted to exceed 1000 meters west on Sunday 1/6/02. A stopping maneuver will be planned and uploaded at 2002007T16:56Z to execute at 2002007T19:48Z.
Trim Maneuver	07 Jan 2002 2002007T19:44:00Z	The burn magnitude will be 8.0 mm/sec with a 180 degree yaw offset. GFO out of point: 007T19:37:00Z - 007T19:50:00Z. The ground track has stopped drifting west and is now drifting back into the ERO. The ground track should be within the 1000 meter limit on 1/12 around 17:11Z.
Trim Maneuver 1 of 2	16 Jan 2002 2002016T23:26:00Z	The total burn magnitude will be 37.87 mm/sec with a 0 degree yaw offset. GFO out of point: 016T23:19:00Z - 016T23:32:00Z.
Trim Maneuver 2 of 2	17 Jan 2002 2002017T01:06:00Z	The total burn magnitude will be 37.87 mm/sec with a 0 degree yaw offset. GFO out of point: 017T00:59:00Z - 017T01:12:00Z.

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Moon Intrusion	26 Jan 2002 2002026T00:32:07Z	The time of the excursion and maximum amplitude is: 00:32:07Z - 00:32:35Z (0.80 degrees max).
Moon Intrusion	26 Jan 2002 2002026T02:12:55Z	The time of the excursion and maximum amplitude is: 02:12:55Z - 02:13:05Z (0.34 degrees max).
Moon Intrusion	26 Jan 2002 2002026T07:50:10Z	The time of the excursion and maximum amplitude is: 07:50:10Z - 07:50:30Z (0.35 degrees max).
Moon Intrusion	26 Jan 2002 2002026T09:30:50Z	The time of the excursion and maximum amplitude is: 09:30:50Z - 09:31:15Z (0.57 degrees max).
Moon Intrusion	26 Jan 2002 2002026T11:11:30Z	The time of the excursion and maximum amplitude is: 11:11:30Z - 11:11:38Z (0.37 degrees max).
Trim Maneuver 1 of 2	28 Jan 2002 2002028T02:08:00Z	The total burn magnitude will be 46.78 mm/sec with a 0 degree yaw offset. GFO out of point: 028T02:01:00Z - 028T02:14:00Z.
Trim Maneuver 2 of 2	28 Jan 2002 2002028T03:48:00Z	The total burn magnitude will be 46.78 mm/sec with a 0 degree yaw offset. GFO out of point: 028T03:41:00Z - 028T03:54:00Z.
Moon Intrusion	30 Jan 2002 2002030T23:30:20Z	The time of the excursion and maximum amplitude is: 23:30:20Z - 23:30:30Z (0.30 degrees max).
Trim Maneuver	31 Jan 2002 2002031T02:11:00Z	The burn magnitude will be 25.6 mm/sec with a 0 degree yaw offset. GFO out of point: 031T02:04:00Z - 031T02:17:00Z.
Moon Intrusion	31 Jan 2002 2002031T01:10:50Z	The time of the excursion and maximum amplitude is: 01:10:50Z - 01:11:00Z (0.34 degrees max).
Moon Intrusion	31 Jan 2002 2002031T02:50:55Z	The time of the excursion and maximum amplitude is: 02:50:55Z - 02:51:25Z (0.74 degrees max).
Moon Intrusion	31 Jan 2002 2002031T04:31:35Z	The time of the excursion and maximum amplitude is: 04:31:35Z - 04:32:00Z (0.77 degrees max).
Trim Maneuver 1 of 2	13 Feb 2002 2002044T00:27:00Z	The total burn magnitude will be 56.2 mm/sec with a 0 degree yaw offset. GFO out of point: 044T00:21:00Z - 044T00:33:00Z.
Trim Maneuver 2 of 2	13 Feb 2002 2002044T02:07:00Z	The total burn magnitude will be 56.2 mm/sec with a 0 degree yaw offset. GFO out of point: 044T02:01:00Z - 044T02:13:00Z.
ERO Violation	19 Feb 2002 2002050T09:09:19Z	GFO will be out of the ERO for approximately two days from 2/19/02 09:09:19 to 2/21/02 14:49:21. The excursion should be no more than 50m West.
Moon Intrusion	23 Feb 2002 2002054T06:18:24Z	The time of the excursion and maximum amplitude is: 06:18:24Z - 06:18:26Z (0.28 degrees max).

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Moon Intrusion	23 Feb 2002 2002054T07:59:05Z	The time of the excursion and maximum amplitude is: 07:59:05Z - 07:59:12Z (0.31 degrees max).
Moon Intrusion	24 Feb 2002 2002055T02:53:25Z	The time of the excursion and maximum amplitude is: 02:53:25Z - 02:53:31Z (0.36 degrees max).
Moon Intrusion	24 Feb 2002 2002055T04:33:55Z	The time of the excursion and maximum amplitude is: 04:33:55Z - 04:33:59Z (0.30 degrees max).
Trim Maneuver 1 of 2	27 Feb 2002 2002058T01:33:00Z	The total burn magnitude will be 50.1 mm/sec with a 0 degree yaw offset. GFO out of point: 058T01:26:00Z - 058T01:39:00Z.
Trim Maneuver 2 of 2	27 Feb 2002 2002058T03:13:00Z	The total burn magnitude will be 50.1 mm/sec with a 0 degree yaw offset. GFO out of point: 058T03:06:00Z - 058T031:19:00Z.
Moon Intrusion	01 Mar 2002 2002061T22:54:34Z	The time of the excursion and maximum amplitude is: 22:54:34Z - 22:54:43Z (0.40 degrees max).
Moon Intrusion	01 Mar 2002 2002061T23:30:27Z	The time of the excursion and maximum amplitude is: 23:30:27Z - 23:30:39Z (0.345 degrees max).
Moon Intrusion	02 Mar 2002 2002062T00:34:39Z	The time of the excursion and maximum amplitude is: 00:34:39Z - 00:35:11Z (0.55 degrees max).
Moon Intrusion	02 Mar 2002 2002062T01:10:38Z	The time of the excursion and maximum amplitude is: 01:10:38Z - 01:11:21Z (0.61 degrees max).
Moon Intrusion	02 Mar 2002 2002062T02:15:11Z	The time of the excursion and maximum amplitude is: 02:15:11Z - 02:15:38Z (0.725 degrees max).
ABCAL	05 Mar 2002 2002064T21:10:00Z	Performed ABCAL Maneuver: 064T21:10:00Z - 064T21:26:00Z. Each off-nadir excursion angle is 0.6 degrees in magnitude.
Trim Maneuver	07 Mar 2002 2002066T04:06:00Z	The burn magnitude will be 28.2 mm/sec with a 0 degree yaw offset. GFO out of point: 066T03:59:00Z - 066T04:12:00Z.
Trim Maneuver 1 of 2	19 Mar 2002 2002078T01:32:00Z	The total burn magnitude will be 47.0 mm/sec with a 0 degree yaw offset. GFO out of point: 078T01:25:00Z - 078T01:38:00Z.
Trim Maneuver 2 of 2	19 Mar 2002 2002078T03:12:00Z	The total burn magnitude will be 47.0 mm/sec with a 0 degree yaw offset. GFO out of point: 078T03:05:00Z - 078T03:18:00Z.
Moon Intrusion	26 Mar 2002 2002085T12:02:27Z	The time of the excursion and maximum amplitude is: 12:02:27Z - 12:02:35Z (0.723 degrees max).
Moon Intrusion	26 Mar 2002 2002085T12:02:37Z	The time of the excursion and maximum amplitude is: 12:02:37Z - 12:02:47Z (0.541 degrees max).

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Moon Intrusion	26 Mar 2002 2002085T13:42:21Z	The time of the excursion and maximum amplitude is: 13:42:21Z - 13:42:27Z (0.348 degrees max).
Moon Intrusion	31 Mar 2002 2002090T07:52:31Z	The time of the excursion and maximum amplitude is: 07:52:31Z - 07:52:39Z (0.358 degrees max).
Moon Intrusion	31 Mar 2002 2002090T09:33:07Z	The time of the excursion and maximum amplitude is: 09:33:07Z - 09:33:17Z (0.793 degrees max).
Moon Intrusion	31 Mar 2002 2002090T09:33:25Z	The time of the excursion and maximum amplitude is: 09:33:25Z - 09:33:31Z (0.361 degrees max).
Moon Intrusion	31 Mar 2002 2002090T11:13:30Z	The time of the excursion and maximum amplitude is: 11:13:30Z - 11:13:36Z (0.380 degrees max).
Moon Intrusion	31 Mar 2002 2002090T15:39:46Z	The time of the excursion and maximum amplitude is: 15:39:46Z - 15:39:54Z (0.433 degrees max).
Moon Intrusion	31 Mar 2002 2002090T15:40:09Z	The time of the excursion and maximum amplitude is: 15:40:09Z - 15:40:17Z (0.407 degrees max).
Moon Intrusion	31 Mar 2002 2002090T17:20:15Z	The time of the excursion and maximum amplitude is: 17:20:15Z - 17:20:26Z (0.574 degrees max).
Moon Intrusion	31 Mar 2002 2002090T17:20:34Z	The time of the excursion and maximum amplitude is: 17:20:34Z - 17:20:46Z (0.460 degrees max).
Trim Maneuver 1 of 2	04 Apr 2002 2002094T03:20:00Z	The total burn magnitude will be 38.6 mm/sec with a 0 degree yaw offset. GFO out of point: 094T03:13:00Z - 094T03:26:00Z.
Trim Maneuver 2 of 2	04 Apr 2002 2002094T05:00:00Z	The total burn magnitude will be 38.6 mm/sec with a 0 degree yaw offset. GFO out of point: 094T04:53:00Z - 094T05:06:00Z.
ERO Violation	12 Apr 2002 2002102T13:57:00Z	(Exceeding ERO Limits) GFO's ground track is going to exceed the -1000m western limit and get to -1239m before turning around. A stopping maneuver will not be performed and the ground track will be allowed to drift back into the ERO limits on its own.
ERO Violation	15 Apr 2002 2002105T00:00:00Z	Over the weekend the drag on GFO increased enough to keep its average ground track from violating the -1000m western ERO limit. The average ground track turned around on 4/13 at -904m. Between 4/12 and 4/15 there were 4 one revolution per day spikes that crossed the -1000m limit. The largest one went to -1033m.
Trim Maneuver	23 Apr 2002 2002113T01:33:00Z	The burn magnitude will be 33.3 mm/sec with a 0 degree yaw offset. GFO out of point: 113T01:26:00Z - 113T01:39:00Z.
Moon Intrusion	24 Apr 2002 2002114T10:40:35Z	The time of the excursion and maximum amplitude is: 10:40:35Z - 10:40:44Z (0.460 degrees max).

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Moon Intrusion	24 Apr 2002 2002114T12:21:08Z	The time of the excursion and maximum amplitude is: 12:21:08Z - 12:21:18Z (0.380 degrees max).
Moon Intrusion	24 Apr 2002 2002114T14:01:27Z	The time of the excursion and maximum amplitude is: 14:01:27Z - 14:01:35Z (0.370 degrees max).
Moon Intrusion	30 Apr 2002 2002120T05:07:15Z	The time of the excursion and maximum amplitude is: 05:07:15Z - 05:07:19Z (0.340 degrees max).
Moon Intrusion	30 Apr 2002 2002120T06:47:43Z	The time of the excursion and maximum amplitude is: 06:47:43Z - 06:47:51Z (0.406 degrees max).
Moon Intrusion	30 Apr 2002 2002120T13:58:37Z	The time of the excursion and maximum amplitude is: 13:58:37Z - 13:58:39Z (0.278 degrees max).
Moon Intrusion	30 Apr 2002 2002120T13:58:55Z	The time of the excursion and maximum amplitude is: 13:58:55Z - 13:58:57Z (0.309 degrees max).
Moon Intrusion	30 Apr 2002 2002120T15:39:22Z	The time of the excursion and maximum amplitude is: 15:39:22Z - 15:39:33Z (0.596 degrees max).
Moon Intrusion	30 Apr 2002 2002120T15:39:41Z	The time of the excursion and maximum amplitude is: 15:39:41Z - 15:39:49Z (0.315 degrees max).
Moon Intrusion	30 Apr 2002 2002120T17:20:00Z	The time of the excursion and maximum amplitude is: 17:20:00Z - 17:20:06Z (0.446 degrees max).
Trim Maneuver	23 May 2002 2002143T00:53:00Z	The burn magnitude will be 20.4 mm/sec with a 0 degree yaw offset. GFO out of point: 143T00:46:00Z - 143T00:59:00Z.
Moon Intrusion	23 May 2002 2002143T13:00:36Z	The time of the excursion and maximum amplitude is: 13:00:36Z - 13:00:45Z (0.438 degrees max).
Moon Intrusion	23 May 2002 2002143T14:41:26Z	The time of the excursion and maximum amplitude is: 14:41:26Z - 14:41:30Z (0.371 degrees max).
Moon Intrusion	23 May 2002 2002143T14:41:45Z	The time of the excursion and maximum amplitude is: 14:41:45Z - 14:41:47Z (0.275 degrees max).
Moon Intrusion	23 May 2002 2002143T17:28:10Z	The time of the excursion and maximum amplitude is: 17:28:10Z - 17:28:21Z (0.908 degrees max).
Moon Intrusion	23 May 2002 2002143T17:28:25Z	The time of the excursion and maximum amplitude is: 17:28:25Z - 17:28:35Z (0.581 degrees max).
Moon Intrusion	23 May 2002 2002143T19:08:52Z	The time of the excursion and maximum amplitude is: 19:08:52Z - 19:08:54Z (0.623 degrees max).
Moon Intrusion	23 May 2002 2002143T19:08:56Z	The time of the excursion and maximum amplitude is: 19:08:56Z - 19:09:06Z (0.619 degrees max).
Moon Intrusion	23 May 2002 2002143T19:09:08Z	The time of the excursion and maximum amplitude is: 19:09:08Z - 19:09:23Z (0.798 degrees max).

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Moon Intrusion	23 May 2002 2002143T20:49:23Z	The time of the excursion and maximum amplitude is: 20:49:23Z - 20:49:34Z (0.744 degrees max).
Moon Intrusion	23 May 2002 2002143T20:49:50Z	The time of the excursion and maximum amplitude is: 20:49:50Z - 20:50:04Z (0.637 degrees max).
Moon Intrusion	23 May 2002 2002143T20:50:15Z	The time of the excursion and maximum amplitude is: 20:50:15Z - 20:50:17Z (0.277 degrees max).
Moon Intrusion	23 May 2002 2002143T22:30:41Z	The time of the excursion and maximum amplitude is: 22:30:41Z - 22:30:45Z (0.312 degrees max).
Trim Maneuver	13 Jun 2002 2002164T23:04:00Z	The burn magnitude will be 13.6 mm/sec with a 0 degree yaw offset. GFO out of point: 164T22:57:00Z - 164T23:10:00Z.
ABCAL	18 Jun 2002 2002169T03:30:00Z	Performed ABCAL Maneuver: 169T03:30:00Z - 169T03:46:00Z.
Moon Intrusion	08 Jul 2002 2002189T18:33:32Z	The time of the excursion and maximum amplitude is: 18:33:32Z - 18:38:32Z (0.291 degrees max).
Moon Intrusion	21 Jul 2002 2002202T15:26:09Z	The time of the excursion and maximum amplitude is: 15:26:09Z - 15:26:30Z (0.580 degrees max).
Moon Intrusion	21 Jul 2002 2002202T17:06:37Z	The time of the excursion and maximum amplitude is: 17:06:37Z - 17:07:02Z (0.650 degrees max).
Moon Intrusion	21 Jul 2002 2002202T18:47:00Z	The time of the excursion and maximum amplitude is: 18:47:00Z - 18:47:32Z (0.400 degrees max).
Moon Intrusion	21 Jul 2002 2002202T20:27:56Z	The time of the excursion and maximum amplitude is: 20:27:56Z - 20:28:03Z (0.350 degrees max).
Trim Maneuver	24 Jul 2002 2002205T19:48:00Z	The burn magnitude will be 20.3 mm/sec with a 0 degree yaw offset. GFO out of point: 205T19:41:00Z - 205T19:54:00Z.
Moon Intrusion	27 Jul 2002 2002208T04:21:45Z	The time of the excursion and maximum amplitude is: 04:21:45Z - 04:21:51Z (0.330 degrees max).
Moon Intrusion	27 Jul 2002 2002208T06:02:07Z	The time of the excursion and maximum amplitude is: 06:02:07Z - 06:02:17Z (0.440 degrees max).
Trim Maneuver	08 Aug 2002 2002220T23:44:00Z	The burn magnitude will be 16.0 mm/sec with a 0 degree yaw offset. GFO out of point: 220T23:37:00Z - 220T23:50:00Z.
Trim Maneuver	22 Aug 2002 2002234T23:11:00Z	The burn magnitude will be 32.7 mm/sec with a 0 degree yaw offset. GFO out of point: 234T23:04:00Z - 234T23:17:00Z.

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Moon Intrusion	25 Aug 2002 2002237T12:46:30Z	The terminology for moon intrusions has changed. Recent analysis of these events has shown that the angles being measured are only the horizon sensor outputs as a result of the moon intrusions. By the time the attitude control system analysis has begun to respond (start to spin up the momentum wheels) and with the satellite inertia to be overcome, any momentary moon intrusion has likely ended before anything more than a negligible spacecraft motion occurs.
Moon Intrusion	25 Aug 2002 2002237T14:26:53Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	27 Aug 2002 2002239T16:04:53Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	27 Aug 2002 2002239T17:45:27Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	27 Aug 2002 2002239T19:26:03Z	Momentary horizon sensor measurements errors have resulted.
ERO Violation	31 Aug 2002 2002243T17:42:00Z	(Exceeding ERO Limits) The current ground track prediction for GFO indicates that the satellite will violate the ERO between 1742Z on 8/31/02 and 2322Z on 9/2/02. It is predicted to only drift to a maximum of 25m west of the boundary. Historically, we have not performed stopping maneuvers for violations of such small magnitude.
Trim Maneuver	13 Sep 2002 2002256T00:00:00Z	The burn magnitude will be 35.2 mm/sec with a 0 degree yaw offset. GFO out of point: 255T23:53:00Z - 256T00:06:00Z.
Moon Intrusion	15 Sep 2002 2002258T17:28:52Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	15 Sep 2002 2002258T19:09:20Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	15 Sep 2002 2002258T20:49:47Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	24 Sep 2002 2002267T05:29:50Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	24 Sep 2002 2002267T07:10:13Z	Momentary horizon sensor measurements errors have resulted.
Trim Maneuver	02 Oct 2002 2002275T23:25:00Z	The burn magnitude will be 35.7 mm/sec with a 0 degree yaw offset. GFO out of point: 275T23:18:00Z - 275T23:31:00Z.

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Anomaly	15 Oct 2002 2002288T00:00:00Z	An apparent satellite encryptor anomaly prevented the ground system from re-acquiring telemetry following the swap to transmitter 2 (omni) at the beginning of today's planned swap to wheel 2,3,4 configuration support. No further commanding was attempted until the following support. On the following support, XM2 was shut off and XM1 was powered on, resulting in the successful re-acquisition of telemetry.
Configuration	16 Oct 2002 2002289T21:13:35Z	The GFO reaction wheel configuration will be modified from wheels 1-2-4 to 2-3-4 during a support between 21:13:15z and 21:24:58z.
Moon Intrusion	17 Oct 2002 2002290T05:23:54Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	17 Oct 2002 2002290T07:04:27Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	17 Oct 2002 2002290T08:44:58Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	17 Oct 2002 2002290T10:25:38Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	17 Oct 2002 2002290T17:40:04Z	Momentary horizon sensor measurements errors have resulted.
Moon Intrusion	17 Oct 2002 2002290T19:20:39Z	Momentary horizon sensor measurements errors have resulted.

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Wheel Alarms	18 Oct 2002 2002291T08:00:00Z	At about 291/0800z, during the first DSU dump (DC 24479) following the recent GPS 4 turn on, NAVSOC DSMs received incoming alarms indicating out-of-limit wheel 1 -15V values. The DSMs notified the GFO lead engineer of these alarms, which reported a value of around -17.55V. Prior to the GPS 4 turn on, this telemetry point had been around -15.5V. Upon arrival to NAVSOC, GFO engineers immediately began evaluating the latest available DSU data. This data confirmed their suspicion that the GFO wheel 1 +/-15V telemetry had begun a steady increase temporally concurrent with the turn on of GPS 4, which occurred at approximately 290/2050z. Ball Aerospace was contacted regarding this situation, and it was decided that on the next available support, (rev DA 24481 @ 291/1142z) GPS 4 should be immediately turned off, the CSM cleared (it still commands), and the in-progress Cal 3 terminated. In addition, Ball directed GFO engineers to perform the recently prepared wheel swap (to wheels 2-3-4) if they observe either wheel 1 +15V or -15V telemetry exceeding 19.0V in magnitude during this or any subsequent supports. The wheel 1 -15V telemetry point was around -18.3V on the first recovery support (DA 24481), so no wheel swap was performed. On the following two supports, GFO engineers continued to monitor wheel 1 +/-15V telemetry closely. DSU dumps were performed on both of these supports, and the data retrieved was immediately analyzed for wheel 1 +/-15V trending. The DSU data indicated that at approximately 291/1400z the wheel 1 +15V and -15V telemetry peaked in magnitude at 18.55V and 18.79V, respectively, before decreasing again. The most recent support (LP 24484 @ 291/1645z) showed the wheel 1 +15V and -15V down to 18.07V and 18.31V in magnitude, respectively. Ball has approved the prepared wheel swap planning products for implementation as soon as practical. This support has been planned for rev DC 24486 @ 291/2013z.
Configuration	18 Oct 2002 2002291T20:13:35Z	The GFO reaction wheel configuration will be modified from wheels 1-2-4 to 2-3-4 during a support between 21:13:15z and 21:24:58z.
Calibration	21 Oct 2002 2002294T00:00:00Z	TTCS/GPS calibration is going to be performed at Det C. The plan is to turn on the GPS receiver Thursday, and begin the calibration Friday.
Trim Maneuver	24 Oct 2002 2002297T00:05:00Z	The burn magnitude will be 26.1 mm/sec with a 0 degree yaw offset. GFO out of point: 296T23:58:00Z - 297T00:11:00Z.
ABCAL	13 Nov 2002 2002317T18:30:00Z	Performed ABCAL Maneuver: 317T18:30:00Z - 169T18:46:00Z.

Table 2-3 GFO Key Events Log (Continued)

Event	Date & Time of Event	Comments
Commanded	14 Nov 2002 2002318T00:00:00Z	Time Bias Correction. 15 microsecond change to bias.
Commanded	14 Nov 2002 2002318T00:00:00Z	Battery heater duty cycle is approximately 33%. Per battery management request the VT level was changed to 5.5 this afternoon.
Trim Maneuver	14 Nov 2002 2002318T23:55:00Z	The burn magnitude will be 22.1 mm/sec with a 0 degree yaw offset. GFO out of point: 318T23:48:00Z - 319T00:01:00Z.
Moon Intrusion	15 Nov 2002 2002319T22:16:04Z	Momentary horizon sensor measurements errors has been caused.
Moon Intrusion	15 Nov 2002 2002319T23:56:44Z	Momentary horizon sensor measurements errors has been caused.
Moon Intrusion	16 Nov 2002 2002320T01:37:18Z	Momentary horizon sensor measurements errors has been caused.
Moon Intrusion	16 Nov 2002 2002320T03:17:21Z	Momentary horizon sensor measurements errors has been caused.
Moon Intrusion	17 Nov 2002 2002321T06:44:21Z	Momentary horizon sensor measurements errors has been caused.
Moon Intrusion	17 Nov 2002 2002321T08:25:05Z	Momentary horizon sensor measurements errors has been caused.
Commanded	26 Nov 2002 2002330T00:00:00Z	The VT level was changed from 5.5 to 6.0 on Tuesday.
Reaction Wheel	27 Nov 2002 2002331T08:00:00Z	In discussions with Mike Weiss this morning he advised us that Ball had some very informative conversations with Interpoint - the mfgr of the wheel controller electronics. Although the good news is that this is a mfgr that is being very open and cooperative in discussions, the bad news is that we basically need to consider Wheel One LOST. After reviewing the events and confirming lot numbers of parts the conclusion is that the erratic behavior we saw earlier was a result of a radiation induced failure to an optical isolator/coupler and that based on prior experience/history this will only continue to get worse and possibly fry the electronics in that wheel. Current plan is to continue as is on wheels 2, 3, and 4 and to modify the onboard ROM so that wheel one does not inadvertently come on.

2.4 GFO Ground Processing Incident Log

The ground processing incident log is a complete list of ground processing problems. These problems are processing incidents that have been noted at NASA Wallops

Flight Facility resulting from either: (a) the processing of ground data at the Payload Operations Center located at NAVOCEANO, or (b) DSU dump failures because of antenna lost telemetry and antenna failure at different Detachments.

Table 2-4 "GFO Ground Processing Incident Log", is the table that indicates the problems. Highlighted entries from 25 November 2001 to 27 November 2002 are the incidents that have occurred since the previous Engineering Assessment Report. The majority of these problems are listed as "Segment data for.....appears to be bad". The determination on these data is that there are more than 40 messages of "Delta Sci Time Gap" per segment, indicating problems with the data. Refer to Section 2.4 GFO Ground Processing Errors, GFO Altimeter Engineering Assessment Report, The First 20 Cycles Since Acceptance (i.e., last year's WFF report), for an example of a log for a segment of data.

The reason for receiving data indicating problems is noisy data in the Payload data file received from NAVSOC in the DSU download. The eng, ra, ra-cal, and wvf data are not filtered for noise, by the direction from the CALVAL team. The CALVAL team wanted to receive the data in the same manner as it is received at the Payload Operations Center (POC).

Table 2-4 GFO Ground Processing Incident Log

Data Type	Data Date	Comments
	29 November 2000 - 2000334	Acceptance
RA	02 December 2000 - 2000337	Segment data for ra 00337_14_28_34 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 14:28 to 20:46.
RA	04 December 2000 - 2000339	Segment data for ra 00339_09_40_47 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 09:40 to 15:09.
RA	06 December 2000 - 2000341	Segment data for ra 00341_09_59_50 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 09:59 to 14:07.
RA	15 December 2000 - 2000341	Segment data for ra 00350_02_11_25 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 02:11 to 11:57.
RA	Unknown	Segment data for ra 03246_13_20_01 with time of 11:47 to 16:33 received. No data was received for ra data segment 01009_11_47_42 which this appears to coincide with. Received this data segment on 2001010.
SDR	09 January 2001 - 2001009	Data segment for sdr01009_11_47_42_16871 appears to be bad. The Receiver Temperature is at a constant value of 34.633205. Segment time is 11:47 to 16:33.
SDR	10 January 2001 - 2001010	Data segment for sdr01010_17_38_13_23271 appears to be bad. The Receiver Temperature is at a constant value of 41.799999. Segment time is 17:38 to 23:59.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
SDR	16 January 2001 - 2001016	Data segment for sdr01016_00_38_03_11687 appears to be bad. The Receiver Temperature is at a constant value of 41.799999. Segment time is 00:38 to 03:59.Data segment for sdr01016_14_35_10_12139 appears to be bad. The Receiver Temperature is at a constant value of 41.799999. Segment time is 14:35 to 17:53.
RA	21 January 2001 - 2001021	Segment data for ra 01021_14_26_17 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 14:26 to 17:00.
NGDR	21 January 2001 - 2001021	ngdr_gfoo_2001021_00001_86175. SSH anomaly due to Doppler problem.
RA	22 January 2001 - 2001022	Segment data for ra 01022_04_12_37 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 04:12 to 11:43.
SDR	22 January 2001 - 2001022	Data segment for sdr01022_04_12_37_27597 appears to be bad. The Receiver Temperature is at a constant value of 30.540167. Segment time is 04:12 to 11:43.
NGDR	22 January 2001 - 2001022	ngdr_gfoo_2001022_00289_86399. SSH anomaly due to Doppler problem.
NGDR	23 January 2001 - 2001023	ngdr_gfoo_2001023_00000_86400. SSH anomaly due to Doppler problem.
NGDR	24 January 2001 - 2001024	ngdr_gfoo_2001024_00001_86399. SSH anomaly due to Doppler problem.
NGDR	25 January 2001 - 2001025	ngdr_gfoo_2001025_00000_86399. SSH anomaly due to Doppler problem.
RA	Unknown	Segment data for ra 00122_20_39_02 with time of 15:53 to 16:30 received. Received this data segment on 2001024.
NGDR	29 January 2001 - 2001029	ngdr_gfoo_2001029_00304_86400. SSH anomaly.
NGDR	30 January 2001 - 2001030	ngdr_gfoo_2001030_00001_86319. SSH anomaly.
NGDR	30 January 2001 - 2001030	"Implementation of CR ADFC-2001-005: Modify Land/ Quality Flag Filtering on GFO NGDRs". The Change Request to modify the land and quality flag filtering on GFO NGDRs was implemented on the operational processing systems at NAVOCEANO. Starting with the NGDRs for DOY 030, we will no longer filter the data for land and quality flags as we have in the past. It will be up to the user to filter NGDR data for land and quality flags from this date forward. During testing of the software change on the backup system at NAVOCEANO, there was a 1 to 1 correlation between the number of SDR records collected and the number of NGDR records produced on any given day.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
SDR	Unknown	Segment data for sdr01032_02_32_49_298 received. Received this data segment on 2001031.
RA	31 January 2001 - 2001031	Segment data for ra 01031_00_09_49 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 00:09 to 04:34.
SDR	31 January 2001 - 2001031	Data segment for sdr01031_00_09_50_15584 appears to be bad. The Receiver Temperature is at a constant value of 38.043720. Segment time is 00:09 to 04:34.
RA	04 February 2001 - 2001035	Segment data for ra 01035_05_48_09 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 05:48 to 18:03.
SDR	05 February 2001 - 2001036	Data segment for sdr01036_02_02_24_11393 appears to be bad. The Receiver Temperature is at a constant value of 41.799999. Segment time is 02:02 to 05:18.
RA	06 February 2001 - 2001037	Segment data for ra 01037_18_43_54 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 18:43 to 19:55.
RA	07 February 2001 - 2001038	Segment data for ra 01038_18_15_42 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 18:15 to 22:01.
RA	08 February 2001 - 2001039	Segment data for ra 01039_19_21_21 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 19:21 to 21:05.
RA	21 February 2001 - 2001052	Segment data for ra 01052_07_03_33 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 07:03 to 17:30.
SDR	21 February 2001 - 2001052	Data segment for sdr01052_07_03_33_38237 appears to be bad. The Receiver Temperature is at a constant value of 33.525787. Segment time is 07:03 to 17:30.
RA	02 March 2001 - 2001061	Segment data for ra 01061_02_27_45 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 02:27 to 07:24.
RA	07 March 2001 - 2001066	Segment data for ra 01066_06_29_42 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 06:29 to 16:55.
RA	07 March 2001 - 2001066	Segment data for ra 01066 NORMS includes FINEL,CAL1,&CAL2.
SDR	08 March 2001 - 2001067	New SDR Software. Modified to improve record timing.
RA	08 March 2001 - 2001067	Segment data for ra 01067 NORMS includes FINEL,CAL1,&CAL2.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	09 March 2001 - 2001068	Segment data for ra 01068 NORMS includes FINEL,CAL1,&CAL2.
RA	10 March 2001 - 2001069	Segment data for ra 01069 NORMS includes FINEL,CAL1,&CAL2.
RA	11 March 2001 - 2001070	Segment data for ra 01070 NORMS includes FINEL,CAL1,&CAL2.
RA	12 March 2001 - 2001071	Segment data for ra 01071 NORMS includes FINEL,CAL1,&CAL2.
RA	13 March 2001 - 2001072	Segment data for ra 01072 NORMS includes FINEL,CAL1,&CAL2.
SDR	13 March 2001 - 2001072	New SDR Software modified at 1700Z. Revision to correct Cal/Val file errors and lack of full waveform data caused by incorrect SDR software.
SDR	Unknown	Segment data for sdr01080_18_08_19_1413 received. Received this data segment on 2001079.
RA	04 April 2001 - 2001094	Segment data for ra 01094_22_55_14 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 22:55 to 095T07:45.
SDR	Unknown	Segment data for sdr01099_08_35_45_4333 received. Received this data segment on 2001098.
RA	03 May 2001 - 2001123	Segment data for ra 01123_10_34_23 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 10:34 to 16:04.
RA	04 May 2001 - 2001124	Segment data for ra 01124_23_13_24 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 23:14 to 125T07:43.
RA	22 May 2001 - 2001142	Segment data for ra 01142_02_38_13 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 02:38 to 08:55.
SDR	Unknown	Segment data for sdr01145_11_29_27_35696 received. Received this data segment on 2001145. Data is actually for day 144 time 11:29 to 21:22. The Receiver Temperature is at a constant value of 37.16.
RA	07 June 2001 - 2001158	Segment data for ra 01158_04_21_18 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 04:21 to 10:38.
SDR	Unknown	Segment data for sdr01161_13_13_27_4401 received. Received this data segment on 2001160. Data is actually for day 160 time 13:13 to 14:35. The Receiver Temperature is at a constant value of 38.0566.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	15 June 2001 - 2001166	Segment data for ra 01166_03_34_05 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 03:34 to 11:31.
RA	20 June 2001 - 2001171	The start of Full waveform data. Erroneous CAL/VAL data generated.
RA	25 June 2001 - 2001176	Segment data for ra 01176_05_04_43 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 05:44 to 08:11.Segment data for ra 01176_14_37_56 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 176t14:37 to 177t01:13.
RA	02 July 2001 - 2001183	Segment data for ra 01183_01_50_19 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 01:50 to 02:45.
RA	05 July 2001 - 2001186	Segment data for ra 01186_04_56_05 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 04:56 to 09:52.
RA	12 July 2001 - 2001193	Segment data for ra 01193_04_59_32 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 04:59 to 09:24.
RA	23 July 2001 - 2001204	Segment data for ra 01204_04_43_23 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 08:13 to 12:17.
RA	28 July 2001 - 2001209	Segment data for ra 01209_17_33_24 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 209t17:33 to 210t09:14.
RA	30 July 2001 - 2001211	New software patch installed. Modified to capture all full waveform data.
RA	Unknown	Segment data for 00122_20_39_03 received. Received this data segment on 2001209.
RA	03 August 2001 - 2001215	Segment data for ra 01215_15_31_02 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 215t15:31 to 216t04:23.
RA	07 August 2001 - 2001219	Segment data for ra 01219_17_24_50 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 219t17:24 to 220t02:53.
RA	08 August 2001 - 2001220	Segment data for ra 01220_18_32_47 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 220t18:32 to 221t05:09.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	09 August 2001 - 2001221	Segment data for ra 01221_18_01_38 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 221t18:01 to 222t04:18.
SDR	27 August 2001 - 2001239	The ADFC has implemented the software patch, provided by Ball, to correct the generation of anomalous SDR files due to the presence of duplicate VTCW in the RA frames. The first sdr produced with the new s/w mod is sdr01239_15_29_41_17989.dat.
RA	Unknown	Segment data for 08080_07_49_27 received. Received this data segment on 2001246.
RA	05 September 2001 - 2001248	Segment data for ra 01248_20_45_07 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 248t20:45 to 249t06:42.
RA	13 September 2001 - 2001256	Segment data for ra 01256_21_37_32 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 256t21:37 to 257t07:50.
RA	17 September 2001 - 2001260	Segment data for ra 01260_21_12_39 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 260t21:12 to 261t07:26.
RA	04 October 2001 - 2001277	Segment data for ra 01277_22_31_01 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 277t22:31 to 278t08:39.
RA	05 October 2001 - 2001278	Segment data for ra 01278_12_21_47 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 278t12:21 to 278t18:39.
RA	14 October 2001 - 2001287	Segment data for ra 01287_23_56_24 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 287t23:56 to 288t10:09.
RA	16 October 2001 - 2001289	Segment data for ra 01289_13_20_55 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 289t13:20 to 288t18:01.
RA	21 October 2001 - 2001294	Segment data for ra 01294_12_27_22 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 294t12:27 to 294t20:25.
RA	25 October 2001 - 2001298	Segment data for ra 01298_19_59_38 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 298t19:59 to 298t23:15.
RA	09 November 2001 - 2001313	Segment data for ra 01313_14_23_10 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 313t14:23 to 313t17:30.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	25 November 2001 - 2001329	Segment data for ra 01329_16_00_39 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 329t16:00 to 329t19:07.
RA	30 November 2001 - 2001334	Segment data for ra 01334_09_43_19 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 334t09:34 to 334t13:02.
RA	Unknown	Segment data for 00135_08_01_19 received. Received this data segment on 2001345.
RA	12 December 2001 - 2001346	Segment data for ra 01346_17_12_33 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 346t18:10 to 346t23:31.
SDR	19 December 2001 - 2001353	Data segment for sdr01353_23_16_37_2656 appears to be bad. The Receiver Temperature is at a constant value of 35.248192. Segment time is 23:16 to 23:59.
RA	01 January 2002 - 2002001	Segment data for ra 02001_12_43_44 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 001t12:40 to 001t17:46.
RA	04 January 2002 - 2002004	Segment data for ra 02004_18_39_55 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 004t19:36 to 004t21:46. Time gaps 0.0000000199 apart.
RA	09 January 2002 - 2002009	The last three hours (19:20z to ~22:30z) of the full waveform data for 1/9/02 was not performed due to a ground station problem during a GFO support that left the DTU in "Normal" rather than "Cal" format.
RA	12 January 2002 - 2002012	Segment data for ra 02012_13_37_49 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 012t15:39 to 012t18:38.
RA	16 January 2002 - 2002016	Segment data for ra 02016_19_07_26 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 016t19:07 to 016t23:55. Time gaps 0.0000000199 apart.
RA	09 February 2002 - 2002040	A personnel error occurred during the DC20898 DSU dump support, resulting in the initial loss of 00:38:40 of DSU data (data gap: 23:17:17 - 23:55:57 on DOY 040). In an effort to recover the lost data, this section was re-dumped during rev DC20904. Therefore, a majority of the lost DSU data should now be recoverable. Note that a portion of the DC20904 dump file will be out of sequence with the preceding dump file (DC20898), so some programmer able data files at both NAVSOC and the POC.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
SCC Clock Pairs	10 February 2002 - 2002041	Edward Grucza (NAVSOC Programmer) identified and corrected the problem that was preventing HQ ISCS from generating SCC.DAT files throughout the weekend. As a result, a new SCC was generated at 10-Feb-2002 20:46:52. The previous SCC was computed on day 040 (9-Feb-2002) at around 0800Z. This time correlates with the last LP support run prior to the LP antenna being stowed due to high winds. For the remainder of the weekend, only the DetA TTCS was available to generate SCC clock pairs. However, the process_rng_files process at the DetA TTCS crashed, apparently as a result of excessive .rng files in the DOC_recv directory. This resulted in a core dump in the TTCS. Once the older .rng files were moved to the raw_archive directory, leaving only the latest .rng file, the process_rng_files process ran successfully. This produced the .dat file used by HQ ISCS to generate the latest SCC.dat.
RA	16 February 2002 - 2002047	Due to an ACU crash in the middle of rev DC 20998, a segment of DSU data was initially lost. Greg Mayer (GD) ran a data recovery support on the following pass (DC 20999) in which he was able to recover a majority of the lost data, with the exception of the following segment: 16-FEB-02 23:59:44 to 17-FEB-02 00:02:57. Due to an operator error, the DSU dump on rev DC 21019 was not performed. The POC Listener was down at HQ this entire weekend starting at about 2/16/02 00:00:00z. As a result, HQ was unable to ingest DSU data from the remote sites, process SCCs from clock pairs, or receive SCC alarms. All data to be ingested and all SCC processing to be brought up to date. GFO will be drifting 140m outside of the western 1 km boundary of the ERO over the next few days. It will exit the boundary at approximately 2/19/02 03:00:00z and re-enter the boundary at approximately 2/23/02 10:00:00z. The DOC has been dropping all HQ Doppler passes throughout the weekend due to RMS exceeding limits. Investigation into the cause of this problem will continue on Tuesday.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
TTCS	25 February 2002 - 2002056	This morning, around 15:00z we received an alarm stating that 15 hours had passed since a gfo clock pair was collected. Apparently, a noisy file was created and sent to the DOC at 00:00z today for DOY 056. At 00:40z today, a noisy .RAW file came to the DOC and the makeranges script attached a range that was more than 10000m. This was greater than the format of the .RNG file so asterisks were placed in the field instead of a valid range. When the TTCS ran the process_range_files script on the file, the script crashed and no more files were processed until it was restarted this morning. A total of seven noisy files were created and sent to the DOC. The entire SCC generation process is now running again and a valid SCC was generated this morning. We will monitor this closely to ensure that SCC generation.
RA	25 February 2002 - 2002056	Missing eng_data02056_20_02_12. We have investigated the lack of delivery of the file and have found a problem with the contents of that file, as well as the next eng_data file, eng_data02057_01_43_37. Neither of those files passed our UNCLASS to CLASS security check and were not released. We have plotted the files and found significant noise at the tail end of eng_data02056_20_02_12 and the beginning of eng_data02057_01_43_37 and believe this condition is the culprit. We have forwarded the POC datafiles to Ball for their inspection. Also, NAVSOC delivered the following email regarding poor data quality and those suspect data times correlate to the rejected eng_data files. At approximately 2000Z, the DTU on GFO was commanded to NORM and the RA commanded to TRK1 in preparation for some table uploads. Some problems occurred during the last GFO pass which prevented us from sending the commands to switch the DTU to CAL and the RA to TRK3 at the conclusion of the pass. The impact: From 2000Z to 0025Z, the RA will be in normal data collection mode (TRK 1 and DTU NORM) instead of full-waveform (TRK 3 and DTU CAL). From 0025Z to 0235Z, commands stored in CSM will switch the RA to TRK3, but since the DTU will remain in NORM, data will be degraded for this period of time. Unfortunately, there are no passes available prior to 0235Z to remedy this. Table 42 was planned to be uploaded on this same pass, but was not able to be sent.
Table Change	26 February 2002 - 2002057	Inserted an attitude bias change to lower off-nadir. Starting segment 2002057T19:33:00

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	06 March 2002 - 2002065	Due to the sequence of passes in the current NRHSCC file, the system is currently not correctly identifying TMON path delay pass types. The SCC's generated and distributed during JD 65 all have this flaw and will generate significant timing errors if used (potentially on the order of 40+ microseconds). We should be able to get the system back on line after the post maneuver orbit is generated and we have more DSU path delay type data (before noon local west coast time 3/7).
RA	10 March 2002 - 2002069	POC sender is operating intermittently. As a result, not all GFO payload data is being sent out.NAVSOC did not send the Payload Operational Center the following Orbits the were on are schedule for day 069 Orbit rev 21309, and for day 070 orbit rev 21321. NAVSOC report that they are having processing problems and are looking into the problem. It appears were are missing data for the following approximate times: day 069 16:11 - 20:00 and for day 070 05:42 - 15:52.
RA	13 March 2002 - 2002072	Segment data for ra 02072_20_07_17 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 072t20:07 to 072t23:00.
RA	13 April 2002 - 2002103	Segment data for ra 02103_04_00_26 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 103t05:28 to 103t08:36.
RA	13 April 2002 - 2002103	Segment data for ra 02103_22_25_29 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 104t02:46 to 104t07:06.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	25 April 2002 - 2002115	The ADFC has not received the latest GFO DSU dumps because of commanding problems at Det A, Prospect Harbor, ME. For the two scheduled DSU dumps; orbits 21975 & 21976, Det A was unable to command the satellite to download data. Due to the duration (~19.5 hrs) from the last successful DSU dump, ~23:00 04/25/02, orbit 21955, to next available dump time, ~18:24, Det C orbit 21981, NAVSOC projects a loss of approximately 4.5 hours of RA data. During this time span, the satellite was in a ra_cal cycle utilizing more storage resources than in normal ra collection. NAVSOC will attempt another Det C download, also orbit 21981 @ ~ 20:00. If this second DSU dump is successfully delivered to the POC and problems at Det A are resolved, then normal operations will resume with the next Det A download @ ~23:57. In addition, it should be noted that in order to maximize our recovery efforts on the 1824z pass (Rev 21981) today, we will be leaving the satellite in Mode 2 until the next planned DSU dump at 2000z (since we currently do not have any DDL users). We are anticipating the RA data loss from approximately 25 April 2300z to 26 April 0330z and will notify the appropriate parties of the actual times when they are available to us.
RA	27 April 2002 - 2002117	Segment data for ra 02117_05_15_31 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 117t05:15 to 117t06:34.
RA	28 April 2002 - 2002118	Due to commanding problems at DetA, the following DSU supports will be cancelled: DOY 119, Rev. 22018, Rev. 22019.
RA	16 May 2002 - 2002136	Segment data for ra 02136_07_51_06 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 136t08:25 to 136t20:13.
RA	27 May 2002 - 2002147	Segment data for ra 02147_01_13_06 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 147t01:13 to 147t07:27.
RA	29 May 2002 - 2002149	Segment data for ra 02149_01_50_45 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 149t01:50 to 149t05:32.
RA	03 June 2002 - 2002154	Segment data for ra 02154_02_42_12 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 154t02:42 to 154t09:06.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
Data FTP	05 June 2002 - 2002156	We have been experiencing trouble transferring flux data into and doppler data out from NAVSOC. The Pt. Mugu base firewall administrators have been notified of the problem and are working this issue. In the mean-time, our orbit prediction capability is slightly degraded since we do not have the most up-to-date flux information. Our last orbit prediction with up-to-date flux data indicated that our next maneuver should occur around 13-14 June. We continue to work with our network administrators to resolve this issue and inform you of any changes.
RA	06 June 2002 - 2002157	Segment data for ra 02157_07_45_38 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 157t07:45 to 157t07:43.
RA	08 June 2002 - 2002159	Segment data for ra 02159_22_57_28 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 159t22:57 to 160t02:30.
RA	09 June 2002 - 2002160	Segment data for ra 02160_02_48_42 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 160t02:48 to 160t07:50.
RA	11 June 2002 - 2002162	Segment data for ra 02162_03_26_46 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 162t03:26 to 162t09:25.
SDR	11 June 2002 - 2002162	The ADFC has implemented the new VATT software modification. The first sdr produced with the new s/w chg is sdr02162_03_26_47_21350.dat.
Data FTP	12 June 2002 - 2002163	As of 10:00 today, 12 June 2002, the communication disruption between NAVO and your facilities has been corrected. NAVO has successfully delivered altimetry products to your respective servers and have attempted to catch-up the missed data. Please take a moment to verify you are receiving data and/or are able to deliver data successfully. After verification of receipt capabil-ity, please try to determine what data was not delivered and notify NAVO. NAVO will try to get everyone caught up.The latest word received about the cause indicated a problem somewhere between NAVO and the facilities in the Maryland/D.C. area. Apparently, there was a router/switch that was causing all the prob-lems.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	14 June 2002 - 2002165	Due to ground system difficulties and subsequent efforts to recover impacted data, DSU data files representing times between 165/23:11:55z and 166/12:44:34z will include some redundant, some out-of-sequence, and some lost segments. It is currently estimated that the total amount of unrecoverable data is around 4 hours and 15 minutes. Any estimates communicated prior to the receipt of this message should be disregarded. On Monday, NAVSOC programmers and General Dynamics engineers will evaluate and manipulate the DSU data files from the affected period in an effort to ensure the minimum loss of DSU data. The POC should expect not to receive DSU data files from revs 22687 and 22699, which were previously scheduled as DSU dumps. The POC will however receive a file from rev 22701, which was not previously scheduled as a DSU dump.
RA	19 June 2002 - 2002170	Segment data for ra 02170_08_34_14 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 170t08:34 to 170t10:50.
RA	20 June 2002 - 2002171	Segment data for ra 02171_23_26_37 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 171t23:26 to 172t04:57.
Antenna Failure	21 June 2002 - 2002172	Due to a hardware failure of the antenna at Det A on 06/21/2002, operations and data collection for GFO will be modified for this weekend and possibly for at least a week. All passes at Det A after and including Rev#22787 have been nulled. All feasible passes at Det C after and including Rev#22792 will be DSU Dumps. Revised schedules will be sent via e-mail. Because of the pass interval at Det C and GFO's DSU capacity restrictions, we will not be able to perform full waveform collection until further notice. We will, however, plan RA CAL 1 sequences twice a day until further notice. From approximately 1114Z on DOY 173 to 0008Z on DOY 174, GFO remained in Mode 2 to facilitate commanding, but thereafter will continue to perform normal DDL mode switching. Another consequence of the Det A antenna problem is that SCCs cannot be produced from the site. We are currently investigating the feasibility of generating operational SCCs from Det C during the interim and will notify you of the results.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
Antenna Failure	22 June 2002 - 2002173	(Notification at 6:14PM) The contents of the CSM have been cleared and filled with commands to perform DSU Dumps at Det C, DDL mode-switching, and RA1 Calibrations through Monday 06/24/2002. The Det A antenna was tested on UFO 6 and is possibly operational again. We will attempt to run telemetry monitor supports at Det A for the remainder of the weekend. The Det C TTCS has been brought up to operational status as of Rev#22799 in response to Detachment Alfa's antenna failure but is not producing completely reliable data. We will continue to investigate this and ensure operational SCCs are distributed. (Notification at 7:51PM) DET A has been successfully restored. DET A is tracking and generating timing data normally now. We will monitor its performance over the weekend. If it remains stable over Sunday, then we will resume normal operations late zulu Monday.
RA	22 June 2002 - 2002173	Segment data for ra 02173_11_19_09 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 173t11:19 to 173t21:43.
RA	23 June 2002 - 2002174	Segment data for ra 02174_19_35_14 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 174t19:35 to 175t02:05.
RA	25 June 2002 - 2002176	Segment data for ra 02176_14_34_43 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 176t14:34 to 176t23:51.
RA	26 June 2002 - 2002177	Segment data for ra 02177_08_56_59 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 177t10:33 to 177t21:45.
RA	28 June 2002 - 2002179	Segment data for ra 02179_03_00_04 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 179t03:00 to 179t04:21.
RA	29 June 2002 - 2002180	Segment data for ra 02180_01_45_25 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 180t01:45 to 180t04:25.
RA	29 June 2002 - 2002180	Segment data for ra 02180_04_25_57 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 180t04:45 to 180t08:17.
RA	29 June 2002 - 2002180	Segment data for ra 02180_08_17_28 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 180t08:17 to 180t09:23.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	30 June 2002 - 2002181	Segment data for ra 02181_00_54_06 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 181t00:54 to 181t03:28.
Data Loss	02 July 2002 - 2002183	Prior to the Det A Rev 22931 (0411Z) DSU Dump, the antenna's counter-balance experienced a malfunction which caused that pass and the next Det A Rev 22932 pass (0549Z) to fail. No data was lost on these two passes, however, as a consequence of not dumping on these two passes, the DSU overwrote by approximately 42 minutes. It is estimated that the loss was between 0024Z and 0106Z on 07/02/2002. On the Det C Rev 22936 pass (1241Z), we manually switched GFO out of DDL mode in order to jump the record pointer and dump DSU data ahead of it before it was overwritten. On the subsequent Det A Rev 22937 pass (1349Z), we experienced another antenna failure (this time due to cable wrap) during the DSU dump. As a consequence, the small portion of data dumped during the time that the antenna was off-track (approximately 97 pages) will need to be recovered this afternoon on the Det C Rev 22942 pass (2345Z).
RA	02 July 2002 - 2002183	Segment data for ra 02183_07_48_52 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 183t08:37 to 184t08:02.
Antenna Failure	03 July 2002 - 2002184	We have been having significant antenna problems at both Det A and Det C (LP is down for a 6 month overhaul). We stopped all but two cal ones a day (that is what we were supposed to do but blew it and was only doing one) so we did not overwrite or at least minimally overwrite data. Hopefully we will be back to normal this week. You can't believe how many times the antenna at Det A wrapped the cable around itself and if it were not for the safety we would have more problems.
RA	03 July 2002 - 2002184	Stopped receiving full waveforms and started receiving one cal per day.
RA	10 July 2002 - 2002191	Segment data for ra 02191_06_44_12 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 191t06:44 to 191t13:11.
SDR	10 July 2002 - 2002191	Data segment for sdr02191_06_44_12_23047 appears to be bad. The Receiver Temperature is at a constant value of 32.652637. Segment time is 06:44 to 13:10.
RA	11 July 2002 - 2002192	Started receiving two cals per day.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	13 July 2002 - 2002194	Segment data for ra 02194_04_23_59 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 194t04:23 to 194t13:19.
RA	18 July 2002 - 2002199	Started receiving full waveforms.
RA	18 July 2002 - 2002199	Segment data for ra 02199_21_44_26 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 199t21:44 to 200t05:10.
RA	20 July 2002 - 2002201	Segment data for ra 02201_06_34_41 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 201t06:34 to 201t10:30.
RA	23 July 2002 - 2002204	Segment data for ra 02204_12_47_37 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 204t13:16 to 204t16:24.
RA	24 July 2002 - 2002205	Segment data for ra 02205_06_16_25 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 205t06:16 to 205t10:54.
RA	27 July 2002 - 2002208	Segment data for ra 02208_06_20_08 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 208t06:20 to 208t10:46.
Antenna Failure	27 July 2002 - 2002208	On Friday evening (DOY 208) Det A experienced another two HPA failures during GFO supports. Given the recent frequency of problems with this HPA, it was subsequently decided by NAVSOC that Det A's commanding capability should be considered unreliable throughout this weekend for GFO operations purposes. As such, GFO has been placed in permanent mode 2 and has had its CSM cleared of commands. A new CSM will be uploaded on rev 23302 at 209/0150z which will contain playback safeties for all supports, and occur until reflect the changes appropriate for this reduced operations mode.
RA	28 July 2002 - 2002209	Stopped receiving full waveforms and started receiving one cal per day.
RA	29 July 2002 - 2002210	Started receiving two cals per day.
Antenna Failure	30 July 2002 - 2002211	A CSM was sent out this morning that will return GFO to normal ops starting Tuesday zulu. Full Waveform Data will be collected again via the Cal 3 sequence and the satellite will be performing DDL mode switching.
RA	30 July 2002 - 2002211	Started receiving full waveforms.
RA	30 July 2002 - 2002211	Segment data for ra 02211_10_34_53 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 211t10:49 to 211t16:08.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	31 July 2002 - 2002212	Segment data for ra 02212_13_36_43 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 212t13:36 to 212t17:15.
RA	02 August 2002 - 2002214	Segment data for ra 02214_07_13_46 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 214t07:13 to 214t10:53.
RA	02 August 2002 - 2002214	Segment data for ra 02214_10_53_56 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 214t10:55 to 214t16:15.
RA	03 August 2002 - 2002215	Segment data for ra 02215_06_03_31 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 215t06:03 to 215t07:42.
RA	03 August 2002 - 2002215	Segment data for ra 02215_14_34_47 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 215t14:34 to 215t17:21.
RA	06 August 2002 - 2002218	Segment data for ra 02218_06_10_43 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 218t06:10 to 218t07:30.
RA	11 August 2002 - 2002223	Segment data for ra 02223_06_54_57 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 223t06:54 to 223t08:34.
RA	21 August 2002 - 2002233	Segment data for ra 02233_08_23_06 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 233t08:23 to 233t13:53.
RA	24 August 2002 - 2002236	Segment data for ra 02236_08_30_29 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 236t08:30 to 236t13:42.
Data Loss	29 August 2002 - 2002241	During processing of the remote site Doppler data between 1200Z 29-Aug 2002 and 1200Z 30-Aug-2002, we discovered that none of the Doppler data from the six Det A passes during that period were collected, the cause of which, is unknown. The impact of this is a slight degradation in that particular orbit run. It appears that Doppler data is now being collected from Det A.
RA	02 September 2002 - 2002245	Segment data for ra 02245_08_51_04 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 245t08:51 to 245t14:00.
RA	08 September 2002 - 2002251	Segment data for ra 02251_09_07_14 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 251t09:07 to 251t11:37.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	09 September 2002 - 2002252	Segment data for ra 02252_16_10_32 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 252t16:10 to 252t19:55.
Antenna Failure	11 September 2002 - 2002254	The Det C Helix antenna is down and the omni antenna is currently collecting doppler data. The previous pass was unusable as further passes will likely be. They have identified a problem and should have parts to repair it by the end of the week. Currently, Det A and HQ are collecting doppler data and, as long as this holds, there should be no problems with the orbit determination. However, tomorrow we will plan a trim maneuver. If the Det A or HQ RDCC goes down, we may not be able to plan this maneuver since we need at least two RDCCs to get a reliable post-maneuver orbit quickly. As it stands now, our ability to determine orbits and plan trim maneuvers is not impacted.
Distribution System	16 September 2002 - 2002259	Unclassified DPSR change. NAVOCEANO is upgrading their automated product distribution system with improved hardware. If your server is running "wrappers", you will have to include the two (2) new IP addresses. NAVO maintains two systems for redundancy purposes, so both machines should be allowed access.We are in the process of transferring the unclassified DPSR function to two new machines for DPD-2002-015. In order to do this, we will need you to add 2 machines into your hosts.allow file if you are running tcp wrappers. Those machines are: UDPS1 128.160.131.66 & UDPS2 128.160.131.67. Change will be Monday, 16 Sept 2002 @ ~ 1400 GMT. The distribution mechanism will remain the same, but new servers will be implemented.
HPA	19 September 2002 - 2002262	The HPA was installed today and it appears to be working properly from tests performed at Det A. Unfortunately, when we tried to communicate with it remotely, we couldn't. As there is only one other Det A pass today and it is below 10 degrees, we will clear the CSM and upload a new table which will put the satellite in 'safe' mode. This is a precautionary measure since we cannot test the command capability of Det A until tomorrow. If the HPA is working properly tomorrow, we will load Wednesday's CSM "Command Storage Memory", as well as Friday's CSM, which will bring GFO into normal operations through the weekend. If, however, the HPA is still not working properly, we will plan and upload a new CSM that will keep GFO in 'safe' mode.
RA	20 September 2002 - 2002263	No full waveforms received today.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
DSU Loss	20 September 2002 - 2002263	1) We discovered a gap in DSU data from 14:47:08 to 15:16:50 on 20-Sep-2002. The POC has confirmed that data received by them was noisy and unusable during this interval as well. The cause for this data loss is unknown and is currently being investigated. 2) Due to a ground system hardware failure, the DSU dump scheduled on Rev 24136 (Det A) was not run. As a consequence, we rescheduled Rev 24141 (Det C) and Rev 24142 (Det A) as DSU dumps (they were not previously planned as such) in order to prevent the DSU from overfilling. GFO was also taken out of DDL mode for the time span between these passes (1739Z to 1856Z) to facilitate dumping.
RA	29 September 2002 - 2002272	Segment data for ra 02272_03_35_15 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 272t03:35 to 272t10:16.
RA	05 October 2002 - 2002278	Segment data for ra 02278_11_47_32 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 278t11:47 to 278t17:50.
RA	05 October 2002 - 2002278	Segment data for ra 02278_17_50_58 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 278t17:50 to 278t18:21.
POC Computer	10 October 2002 - 2002283	Due to failure of the Primary POC Computer, Susie, we have been instructed by the POC to route payload data to Calvin. This change will be effective starting with the DSU dump on REV 24371 at Det C and will continue until further notice.
RA	18 October 2002 - 2002291	At about 291/0800z, during the first DSU dump (DC 24479) following the recent GPS 4 turn on, NAVSOC DSMs received incoming alarms indicating out-of-limit wheel 1 -15V values. At 291/1142z) GPS 4 was immediately turned off, the CSM cleared, and the in-progress Cal 3 terminated. Stopped receiving full waveforms at this time.
RA	25 October 2002 - 2002298	Segment data for ra 02298_18_54_29 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 298t19:41 to 298t22:49.
RA	26 October 2002 - 2002299	Segment data for ra 02299_22_21_46 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 299t22:21 to 300t10:35.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
Data Loss	28 October 2002 - 2002301	Due to commanding problems, a small amount of DSU data was lost today. The lost data was from 18:33:23Z to 18:46:37Z (28-Oct-2002). Due to the small size of this data loss, it has been decided that a recovery attempt is not worth the risk in additional data loss.
SDR	29 October 2002 - 2002302	SWH bounds limit test. The change to the SWH lower bounds, from 0.01 to - 0.01, has been incorporated into operational processing. The next Payload Data that will incorporate the change will be a DC DSU Dump rev # 24644. The first sdr produced with the new s/w mod is 02302_11_32_45_12119.dat.
RA	29 October 2002 - 2002302	Segment data for ra 02302_11_32_45 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 302t12:16 to 302t15:01.
LP Support	31 October 2002 - 2002304	The LP support today (10/31) at 16:42:00 failed. The planned DSU dump did not occur. The RA was configured from Cal 3 mode (Track 3) back to normal data collection mode (Track 1). The RA wasn't returned to Cal 3 mode at the end of the support as planned. So the last 3 hours of the planned RA Cal 3 for today will be collected as normal data instead of full waveform data. The approximate time period of this is from 16:45:00 to 19:55:00.
SCC Generation	31 October 2002 - 2002304	Since Det A is slated to go down due to new hardware installation, we have begun the transition from using Det A to using Det For collection vitamin data for SCC generation. The Rev 24673 Det A pass will be the last one today to generate an SCC using Det A timing. We have reconfigured Det C to collect timing data overnight. After analyzing the SCCs generated by Det C tomorrow morning, we will notify the POC as to whether the SCCs are valid for use. If valid, we will continue to use SCCs generated by Det C while Det A is down, staying with the current 15-microsecond offsetting path delay until the next 17-day repeat orbit.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
DSU Dump	01 November 2002 - 2002305	The DSU Dump at LP rev 24684 at 16:11z this morning failed because the antenna lost telemetry in the middle of the pass. The DSM running the support was able to stop the dump as the signal was getting intermittent and before telemetry was completely lost. Analysis of the support shows that the time of the affected data is approximately 11/1 14:27:00 to 14:45:00. The data in this period will be intermittent with noisy and missing data. During the next support (Det A rev 24687 20:49) the DSU playback pointer will be moved until just before the affected data. No DSU data will be collected by the ground station during this support. Then on Det C rev 24687 21:18, the DSU data will be recollected at the start of the next DSU dump. This will recover the affected data but as some of the data will have been dumped twice, some manual reprocessing may have to be done.
Data Loss	01 November 2002 - 2002305	The DSU Dump at LP rev 24684 at 16:11z this morning failed because the antenna lost telemetry in the middle of the pass. The DSM running the support was able to stop the dump as the signal was getting intermittent and before telemetry was completely lost. Analysis of the support shows that the time of the affected data is 4:27:00 to 14:45:00. The data in this period will be intermittent with noisy and missing data. During the next support (Det A rev 24687 20:49) the DSU playback pointer will be moved until just before the affected data. No DSU data will be collected by the ground station during this support. Then on Det C rev 24687 21:18, the DSU data will be recollected at the start of the next DSU dump. This will recover the affected data but as some of the data will have been dumped twice, some manual reprocessing may have to be done.
RA	01 November 2002 - 2002305	Segment data for ra 02305_12_52_54 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 305t12:52 to 306t04:48.
RA	03 November 2002 - 2002307	Missing waveforms. Data lost from ~15:00 to 17:00 due to corrupted data.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	11 November 2002 - 2002315	Missing waveforms. Waveform data lost from ~17:41 to 18:44. Missing CSM files. On DOY 315, there was a table upload support at LP rev# 24828, AOS 17:41z - LOS 17:49z. The support was performed during RA Cal sequence (during Full Wave-form data collection). Since we need to perform a vote-and-compare (verification) for the uploaded table, and since we cannot perform a vote-and-compare during RA Cal sequence, we have commanded the satellite to stop RA Cal (switch to NORM) for the duration of the table upload (~8 minutes), and intended to command the satellite to restart RA Cal sequence once the table upload was finished.The table upload support was not successful due to NCEU problems (refer to the weekly summary 02317ws.txt). The commanding capability could not be recovered, and RA Cal sequence could not be restarted. The satellite started "Cal I / Cal II" at 18:44z by the commands in the CSM as scheduled.Thus, this explains data that was lost was between 17:41z to 18:44z on DOY 315.
Timing Bias	14 November 2002 - 2002318	During the recent calibration of the three ground sites (as a result of the upgrades in progress) we found that there existed about a 15 microsecond bias in the ground based time tagging system that had not been taken out previously. We will be adjusting the time system for that bias as of 0001Z on 14 November which is the beginning of a new data cycle, at least as the Navy measures those cycles (from the acceptance of the sat by the Navy).
RA	14 November 2002 - 2002318	Segment data for ra 02318_17_57_20 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 318t17:57 to 318t21:01.
RA	18 November 2002 - 2002322	Missing waveforms. Waveform data lost from ~17:25 to 18:37. During a table upload at LP this morning, the satellite was brought out of the cal configuration and brought into the normal configuration so that we could perform our table uploads. The LP NCEU dropped a command during the CSM upload and, as a result, the satellite was not brought back to the cal configuration. Full waveform data collection began at 13:46:58z and was interrupted around 17:25z. The CSM will command the satellite back into the cal configuration for the second full waveform data collection starting at 18:36:58z. As a result roughly one hour of full waveform data will not be collected today.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	21 November 2002 - 2002325	Missing waveforms. Waveform data lost from ~17:32 to 18:33. During a table upload at LP today, we interrupted the Cal sequence. Due to NCEU commanding problems, we could not command the DTU and the RA back to the Cal state. This will result in about an hour less full waveform data than expected from the first data collection period today.
PSK Demod	24 November 2002 - 2002328	The PSK Demod at Det C was swapped out this weekend. The PSK demod is one of the pieces of equipment that can cause a timing shift. As a result, we have halted the production of clock pairs from Det C until we can validate the quality of the resulting SCCs.
PSK Demod	25 November 2002 - 2002329	We have confirmed that the PSK demod switch at Det C has not significantly affected timing. From this point on, all SCCs generated from Det C should be fine.
LP Antenna	25 November 2002 - 2002329	Change in GFO RA Cal data collection. NAVSOC just called and they are going to have to secure the LP antenna for a day or two due to high winds. With only Det C available to retrieve data we are going to temporarily stop the long RA Cal passes and only due the 10 minute ones twice per day.
RA	25 November 2002 - 2002329	Missing waveforms. Waveform data lost from ~17:53 to 18:49. DSU data was lost from about 17:53 to 18:49. It is believed this loss was caused from the modulation of GFO's transmitter spontaneously changing from low to high in the middle of a DSU dump.
Transmitter Anomaly	25 November 2002 - 2002329	During an LP DSU pass on November 25, 2002, XM1 toggled between Mod Low and Mod High three times. The satellite started the pass in Mod Low and during the DSU dump, XM1 switched to Mod High. Our DSU data from that pass starts out fine then becomes noisy around the time the transmitter toggled to Mod High. After this, XM1 toggled back to Mod Low and then to Mod High again. Our DSU contact report also shows a two second period of data that correlates with this. During XM1's second and third switch, XM2 mirrored XM1. That is, XM2 went to Mod High and then to Mod Low. No command was issued out of CSM or from the ground to make these changes. Also, there is only one command to change phase modulation index (XMODHI/LO) and this affects both transmitters simultaneously. There is no way for us to command the satellite's transmitters into the configuration we saw.

Table 2-4 GFO Ground Processing Incident Log (Continued)

Data Type	Data Date	Comments
RA	25 November 2002 - 2002329	Segment data for ra 02329_17_14_14 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 329t17:14 to 329t18:48.
Downtime	26 November 2002 - 2002330	Full Waveform data discontinued. Due to downtime at LP, GFO was placed into "data safe mode" for prevention of overwriting payload data. (No DDL mode switching and 2 10 minute RA calibrations instead of 7 hours of full waveform data). The current plan is to leave the satellite in this mode until at least Monday 12/2.
RA	27 November 2002 - 2002331	Segment data for ra 02331_12_25_34 appears to be bad. Noisy time tagging, plus & minus time gaps and time slips. Segment time is 331t12:25 to 331t23:02.

Section 3

Assessment of Instrument Performance

The following sub-sections report several assessments performed by the WFF GFO team. All analysis indicates the altimeter instrument is performing within pre-launch specifications.

Section 3.1 addresses the range noise performance. Section 3.2 shows the groundtrack coverage of full-waveform GFO data for a typical 17-day cycle; these data are acquired for ice studies over southern Greenland. Then, Section 3.3 provides both an update on CAL-2 waveforms and an analysis of GFO's attitude (off-nadir) angles.

3.1 Range Measurement Noise

The GEOSAT Follow-on (GFO) altimeter white noise levels have been evaluated using a new technique based on high-pass filtering of 1-Hz sea surface height time series. High-pass filtering removes the geoid and oceanography signals while revealing the random noise. The new filtering technique is simpler to use than the repeat-track method, gives essentially the same results, and makes it easier to analyze much larger amounts of data to investigate subtle variations in noise levels. The new noise level measurements provided here all show a stable noise process from cycle-to-cycle with a linear dependence of the noise level upon significant waveheight (SWH). The GFO altimeter noise level is estimated to be about 2.57 cm for an SWH of 2m. Table 3-1 summarizes the results.

The data used for Table 3-1 had slightly different data editing criteria than the data that were used in Section 2. The cycle SWH mean is the SWH for the data used in each cycle, and the Noise Level mean is the mean of the noise estimated by the high-pass filter method. The 2m SWH is the noise estimate from fitting the individual noise estimate as a function, then solving the fitted equation for a 2m SWH.

Table 3-1 Statistical Indicators for GFO Based on 1-Minute Track Segments

Time Period			SWH (m)		Noise Level (cm)		
Cycle	Cycle Start Date	Cycle End Date	Mean	STD	Mean	STD	at 2m SWH
01	2000-352	2001-002	2.629	1.221	2.996	1.162	2.542
02	2001-003	2001-019	2.506	1.185	2.903	1.115	2.547
03	2001-020	2001-036	2.552	1.158	3.044	1.271	2.680
04	2001-037	2001-053	2.520	1.144	2.914	1.108	2.545
05	2001-054	2001-070	2.603	1.237	3.006	1.149	2.596
06	2001-071	2001-087	2.644	1.231	3.022	1.123	2.592
07	2001-088	2001-104	2.680	1.242	3.032	1.136	2.573
08	2001-105	2001-121	2.600	1.252	2.962	1.115	2.563
09	2001-122	2001-138	2.605	1.326	3.015	1.212	2.590
10	2001-139	2001-155	2.466	1.258	2.886	1.153	2.560
11	2001-156	2001-172	2.504	1.261	2.906	1.145	2.557
12	2001-173	2001-189	2.674	1.401	3.047	1.282	2.567
13	2001-190	2001-206	2.583	1.379	3.007	1.247	2.599
14	2001-207	2001-223	2.699	1.406	3.059	1.259	2.572
15	2001-224	2001-240	2.561	1.293	2.953	1.161	2.569
16	2001-241	2001-257	2.626	1.435	3.009	1.261	2.572
17	2001-258	2001-274	2.623	1.343	3.006	1.190	2.583
18	2001-275	2001-291	2.612	1.287	2.998	1.164	2.581
19	2001-292	2001-308	2.379	1.141	2.813	1.069	2.552
20	2001-309	2001-325	2.488	1.165	2.898	1.102	2.567
21	2001-326	2001-342	2.404	1.077	2.818	1.023	2.546
22	2001-343	2001-359	2.441	1.143	2.857	1.097	2.555
23	2001-360	2002-011	2.480	1.199	2.922	1.150	2.583
24	2002-012	2002-028	2.453	1.183	2.858	1.108	2.544
25	2002-029	2002-045	2.575	1.198	2.946	1.118	2.553
26	2002-046	2002-062	2.422	1.094	2.820	1.035	2.539
27	2002-063	2002-079	2.500	1.166	2.892	1.074	2.552

Table 3-1 Statistical Indicators for GFO Based on 1-Minute Track Segments (Continued)

Time Period			SWH (m)		Noise Level (cm)		
Cycle	Cycle Start Date	Cycle End Date	Mean	STD	Mean	STD	at 2m SWH
28	2002-080	2002-096	2.608	1.161	2.972	1.103	2.554
29	2002-097	2002-113	2.504	1.217	2.910	1.100	2.574
30	2002-114	2002-130	2.558	1.252	2.959	1.158	2.572
31	2002-131	2002-147	2.543	1.289	2.956	1.215	2.564
32	2002-148	2002-164	2.517	1.245	2.935	1.165	2.573
33	2002-165	2002-181	2.612	1.353	2.989	1.231	2.559
34	2002-182	2002-198	2.513	1.314	2.921	1.206	2.559
35	2002-199	2002-215	2.653	1.427	3.026	1.255	2.579
36	2002-216	2002-232	2.634	1.400	2.994	1.221	2.557
37	2002-233	2002-249	2.527	1.299	2.941	1.162	2.582
38	2002-250	2002-266	2.546	1.366	2.959	1.189	2.591
39	2002-267	2002-283	2.415	1.141	2.859	1.092	2.571
40	2002-284	2002-300	2.482	1.196	2.921	1.112	2.597
41	2002-301	2002-317	2.499	1.228	2.905	1.133	2.569
42	2002-318	2002-334	2.497	1.148	2.905	1.101	2.558

3.2 Groundtrack Coverage for GFO Full-Waveform Data

On 2001, day 171 (June 20), GFO started collecting full waveform data over Greenland. Collection of these waveforms was agreed upon to help study altimeter acquisition times and for the study of changes in the Greenland icesheet.

Because of the limited GFO ground commanding and the fact that all Greenland passes occur on consecutive orbits, it was decided to implement the waveform collection in conjunction with the two daily commanded calibration modes. After the first calibration mode, the GFO altimeter stays in the long format for a duration of five hours and collects waveforms until the second calibration mode is executed. Once the second calibration is completed, the long format is continued for an additional duration of two hours of waveform collection.

Daily, the first calibration mode is commanded prior to the first Greenland overpass and the second calibration mode is commanded five hours later. This provides approximately 7 hours of continuous waveform data per day and provides waveforms for all the ascending and descending passes over Greenland. Figure 3-1 "17

Days of Track Data over Greenland" shows the coverage for 17 days (1 cycle) of data over Greenland.

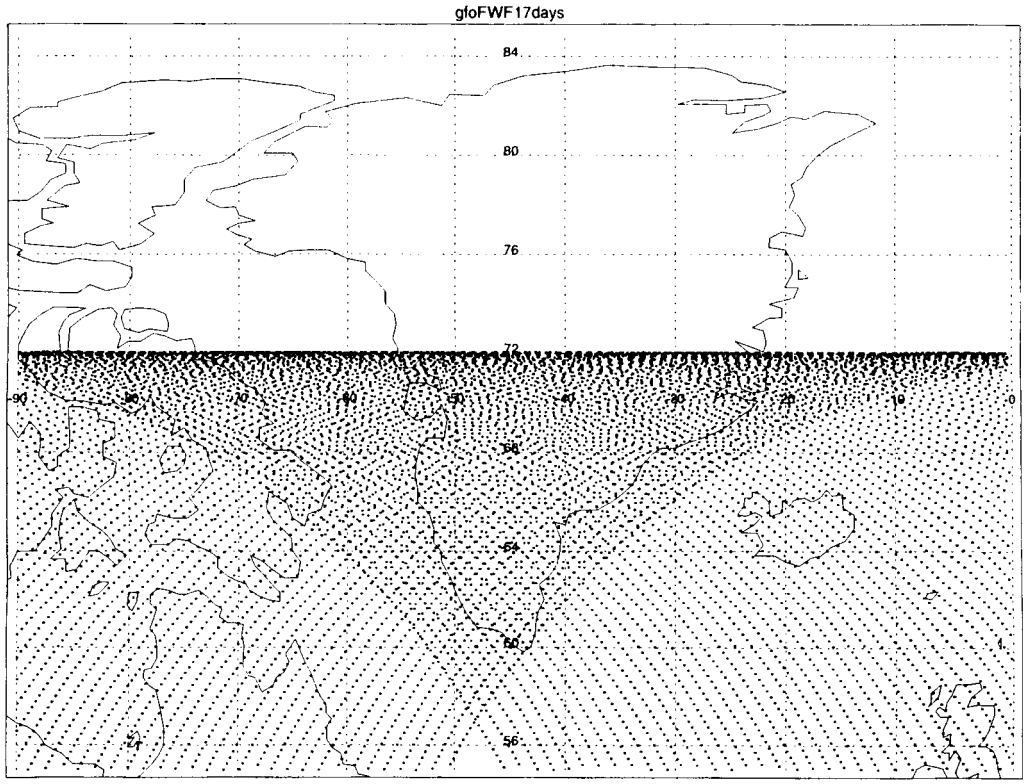

Figure 3-1 17 Days of Track Data over Greenland

The full waveform data was turned off on November 26, 2002 due to ground system problems at Laguna Peak, California. See Table 2-4, GFO Ground Processing Incident Log, for more details.

3.3 Additional Observations

3.3.1 Calibration Mode 2 Waveforms

It was noted in the "GFO Altimeter Engineering Assessment Report, From Launch to Acceptance" that Calibration Mode 2 data should consist of flat waveforms, but the pre-launch data exhibited a "smile" pattern, with both ends of the waveform being higher than the middle. This "smile" introduces errors during normal processing. A software patch (Smile Patch) was developed to correct this by flattening the waveform. During the period from launch to acceptance there were several resets that necessitated the "smile patch" be reloaded. During the period since acceptance there has not been any recurrence of a reset to cause loss of the software patch (Smile Patch) and there are no data that have the "smile" effect.

3.3.2 Attitude

It was noted in the "GFO Altimeter Engineering Assessment Report, The First 20 Cycles Since Acceptance"dated March 2002, that there were much higher than usual numbers of attitudes that were above 0.3 degrees.

It was recommended by WFF that an attitude adjustment be performed. On 2002057, mid-Cycle 26, a spacecraft attitude change was performed by the GFO Project to lower the attitude. In Figure 3-2 "Attitude > .3, Cycle 25", Cycle 25 is shown with a high number of attitudes that were above 0.3 degrees, prior to the attitude adjustment.

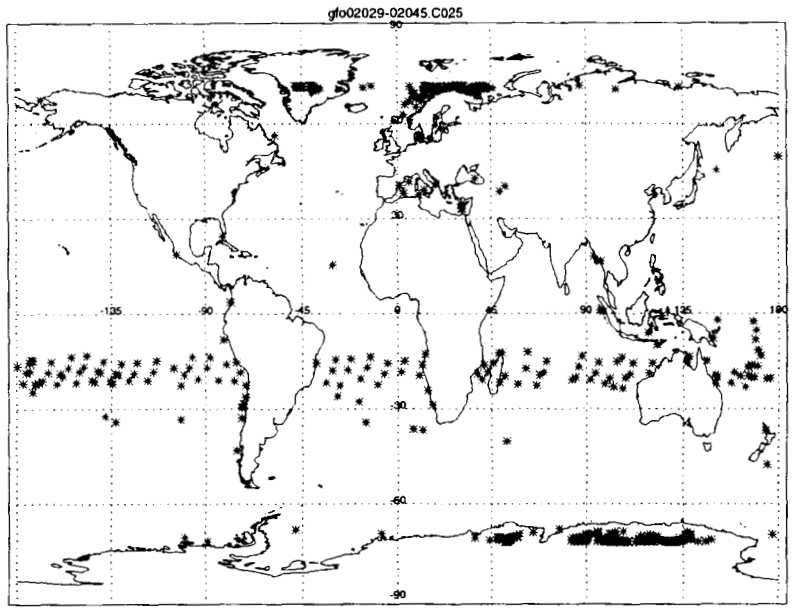

Figure 3-2 Attitude > .3, Cycle 25

A full cycle after the adjustment, Cycle 28, is shown with a much-reduced-number of high attitudes above 0.3 degrees, Figure 3-3 "Attitude > .3, Cycle 28", and with the number of high attitudes above 0.2 degrees, Figure 3-4 "Attitude > .2, Cycle 28" on page 3-6.

In later cycles after the attitude adjustment, Cycle 34 is shown with the number of attitudes above 0.3 degrees, Figure 3-5 "Attitude > .3, Cycle 34" on page 3-7 , and the number of attitudes above 0.2 degrees, Figure 3-6 "Attitude > .2, Cycle 34" on page 3-7. The increased occurrence of attitudes above 0.2 degrees during cycle 34 is believed to be attributable to a seasonal build-up of polar clouds affecting the GFO horizon scanner.

For Cycle 40, the occurrence of attitudes above 0.3 degrees is depicted in Figure 3-7 "Attitude > .3, Cycle 40" on page 3-8, and the occurrence of attitudes above 0.2 degrees, Figure 3-8 "Attitude > .2, Cycle 40" on page 3-8.

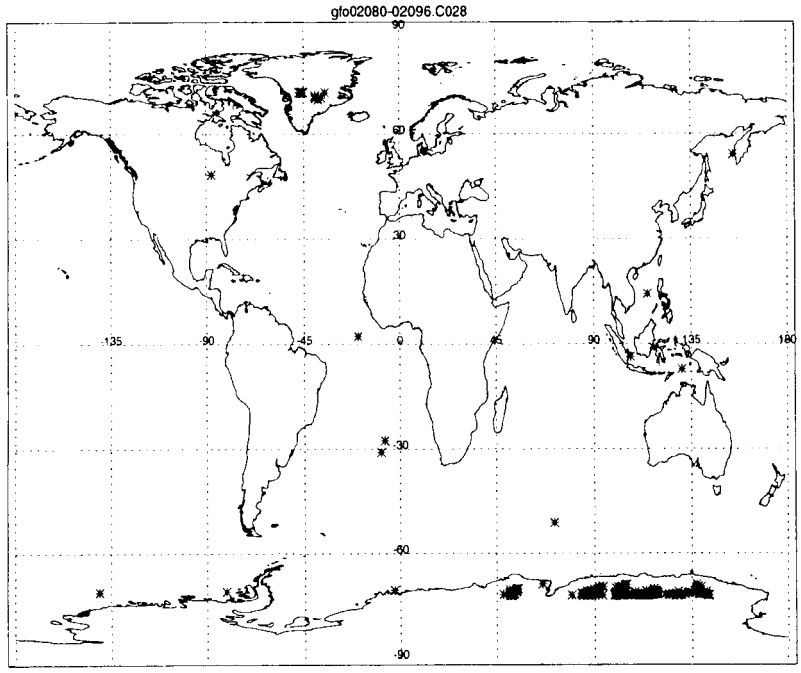

Figure 3-3 Attitude > .3, Cycle 28

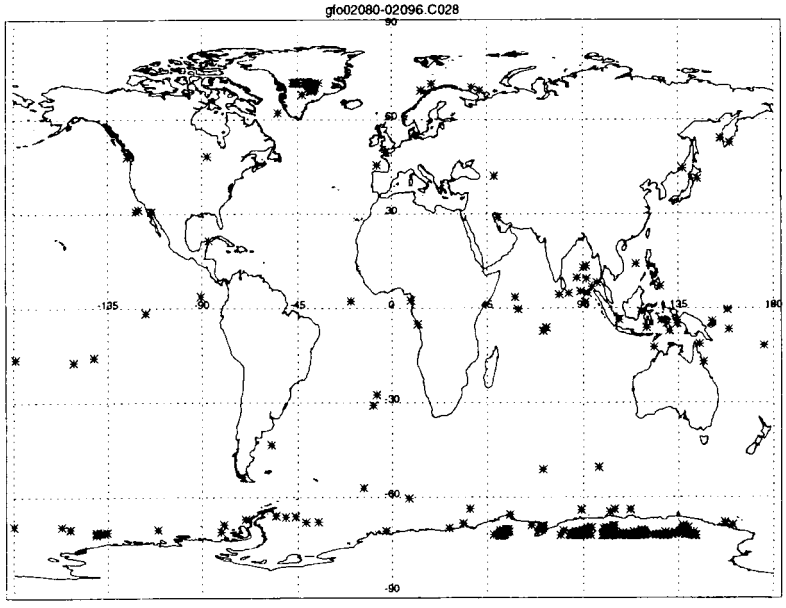

Figure 3-4 Attitude > .2, Cycle 28

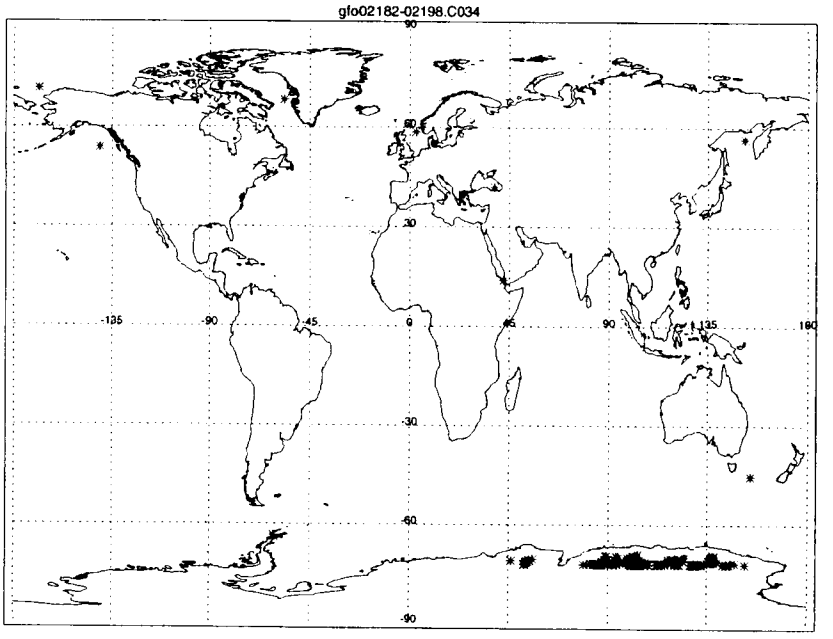

Figure 3-5 Attitude > .3, Cycle 34

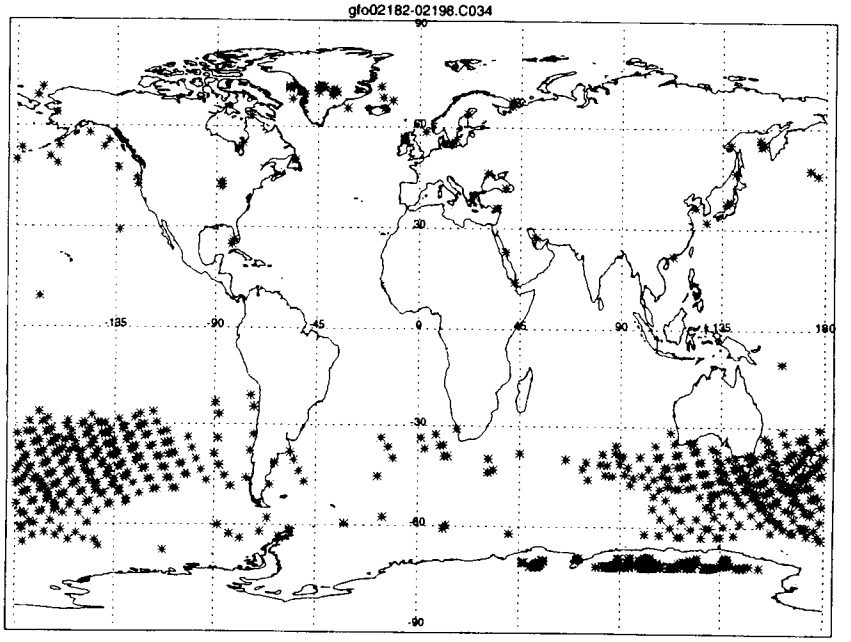

Figure 3-6 Attitude > .2, Cycle 34

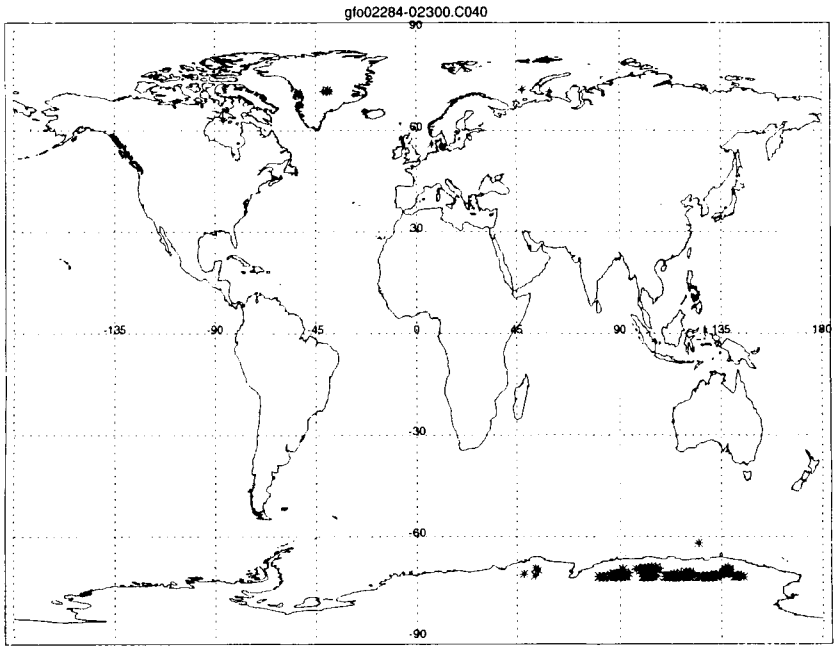

Figure 3-7 Attitude > .3, Cycle 40

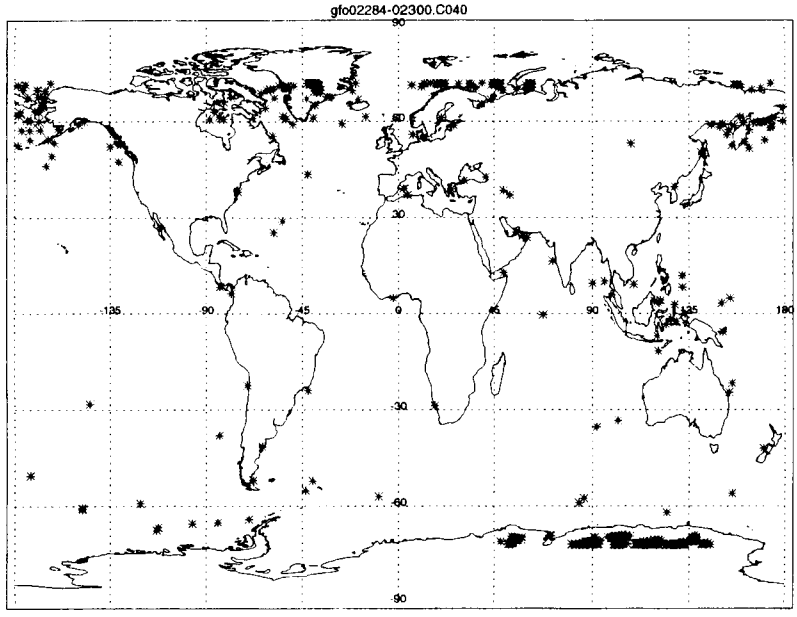

Figure 3-8 Attitude > .2, Cycle 40

Section 4

Other Studies

4.1 GFO Altimeter Wind Speed Monitoring

As part of the validation of GFO data, we monitor the surface wind speed retrieved from the radar cross-section measurements for possible trends. This analysis helps to check the proper functioning of the GFO instrument related to the altimeter return power estimation. For that purpose we use the National Centers for Environmental Prediction (NCEP) winds. The data and method of calculation was noted in the "GFO Altimeter Assessment Report, The First 20 Cycles Since Acceptance".

Table 4-1 "Statistical Indicators", provides the cycle-per-cycle statistical indicators. The comparison shows small biases between GFO and NCEP wind speeds. The averaged bias for a cycle range is between -0.438 m/s and +0.678 m/s, a 1.12 m/s spread.

Figure 4-1 "Plot of Selected Statistical Indicators from Table 4-1" on page 4-4, shows the variations of the averaged value of Sigma0, SWH, GFO wind speed, NCEP wind speed, and the bias between the two wind speed estimates.

Column Definitions for Table 4-1 Statistical Indicators	
cycle	Equivalent to Exactly 17 Days
limit 1	Averaged Value of NCEP - STD NCEP
limit 2	Averaged Value of NCEP + STD NCEP
$<\sigma_0>$	Averaged Value of Sigma0
<SWH>	Averaged Value of SWH
<Ugfo>	Averaged Value of GFO Wind Speed
<Uncep>	Averaged Value of NCEP Wind Speed
<Ugfo> - <Uncep>	Averaged GFO Wind Speed - Averaged NCEP Wind Speed

Table 4-1 Statistical Indicators

cycle	limit 1 (m/s)	limit2 (m/s)	$<\sigma_0>$ (dB)	<SWH> (m)	$<U_{gfo}>$ (m/s)	$<U_{ncep}>$ (m/s)	$<U_{gfo}> - <U_{ncep}>$
1	4.865	11.122	11.526	2.334	7.236	7.618	-0.382
2	4.862	10.885	11.543	2.229	7.190	7.521	-0.331
3	5.039	11.055	11.284	2.313	8.051	7.793	0.258
4	4.896	10.846	11.269	2.288	8.103	7.604	0.499
5	4.558	10.960	11.369	2.307	7.803	7.355	0.448
6	4.498	10.902	11.412	2.327	7.673	7.337	0.336

Table 4-1 Statistical Indicators (Continued)

cycle	limit 1 (m/s)	limit2 (m/s)	$\langle\sigma_0\rangle$ (dB)	$\langle SWH\rangle$ (m)	$\langle U_{gfo}\rangle$ (m/s)	$\langle U_{ncep}\rangle$ (m/s)	$\langle U_{gfo}\rangle - \langle U_{ncep}\rangle$
7	4.746	11.207	11.275	2.413	8.115	7.682	0.433
8	4.836	11.054	11.398	2.278	7.678	7.646	0.032
9	4.660	10.990	11.585	2.258	7.067	7.432	-0.365
10	4.667	10.856	11.566	2.124	7.134	7.379	-0.245
11	4.768	11.025	11.537	2.173	7.213	7.578	-0.365
12	4.968	11.353	11.312	2.312	7.949	7.786	0.163
13	4.740	10.997	11.319	2.233	7.952	7.505	0.447
14	4.836	11.223	11.205	2.326	8.334	7.656	0.678
15	4.763	11.150	11.292	2.239	8.031	7.607	0.424
16	4.534	11.256	11.342	2.255	7.899	7.487	0.412
17	4.627	11.230	11.375	2.247	7.775	7.486	0.289
18	4.694	11.024	11.481	2.287	7.390	7.459	-0.069
19	4.648	10.778	11.589	2.104	7.035	7.365	-0.330
20	4.842	10.962	11.433	2.215	7.544	7.578	-0.034
21	4.909	10.871	11.533	2.156	7.182	7.620	-0.438
22	4.789	10.881	11.366	2.191	7.765	7.518	0.247
23	4.729	10.814	11.372	2.210	7.744	7.376	0.368
24	4.819	10.863	11.291	2.199	8.029	7.559	0.470
25	4.777	11.064	11.280	2.309	8.061	7.604	0.457
26	4.668	10.797	11.366	2.150	7.783	7.384	0.399
27	4.710	11.168	11.333	2.219	7.903	7.589	0.314
28	4.796	11.183	11.337	2.337	7.877	7.730	0.147
29	4.709	10.966	11.520	2.184	7.259	7.575	-0.316
30	4.917	11.123	11.405	2.251	7.617	7.703	-0.086
31	4.578	11.090	11.551	2.203	7.156	7.430	-0.274
32	4.844	11.079	11.345	2.190	7.823	7.617	0.206
33	5.049	11.397	11.153	2.301	8.477	7.881	0.596
34	4.743	11.058	11.284	2.172	8.053	7.507	0.546
35	4.737	11.418	11.248	2.264	8.186	7.665	0.521

Table 4-1 Statistical Indicators (Continued)

cycle	limit 1 (m/s)	limit2 (m/s)	$\langle\sigma_0\rangle$ (dB)	<SWH> (m)	$\langle U_{gfo}\rangle$ (m/s)	$\langle U_{ncep}\rangle$ (m/s)	$\langle U_{gfo}\rangle - \langle U_{ncep}\rangle$
36	4.769	11.349	11.239	2.272	8.210	7.679	0.531
37	4.676	11.142	11.316	2.207	7.958	7.575	0.383
38	4.648	11.198	11.436	2.160	7.554	7.503	0.051
39	4.977	10.996	11.499	2.148	7.300	7.737	-0.437
40	4.642	10.916	11.599	2.173	7.006	7.417	-0.411
41	4.847	11.046	11.468	2.201	7.404	7.662	-0.258
42	4.915	10.957	11.304	2.245	7.970	7.674	0.296

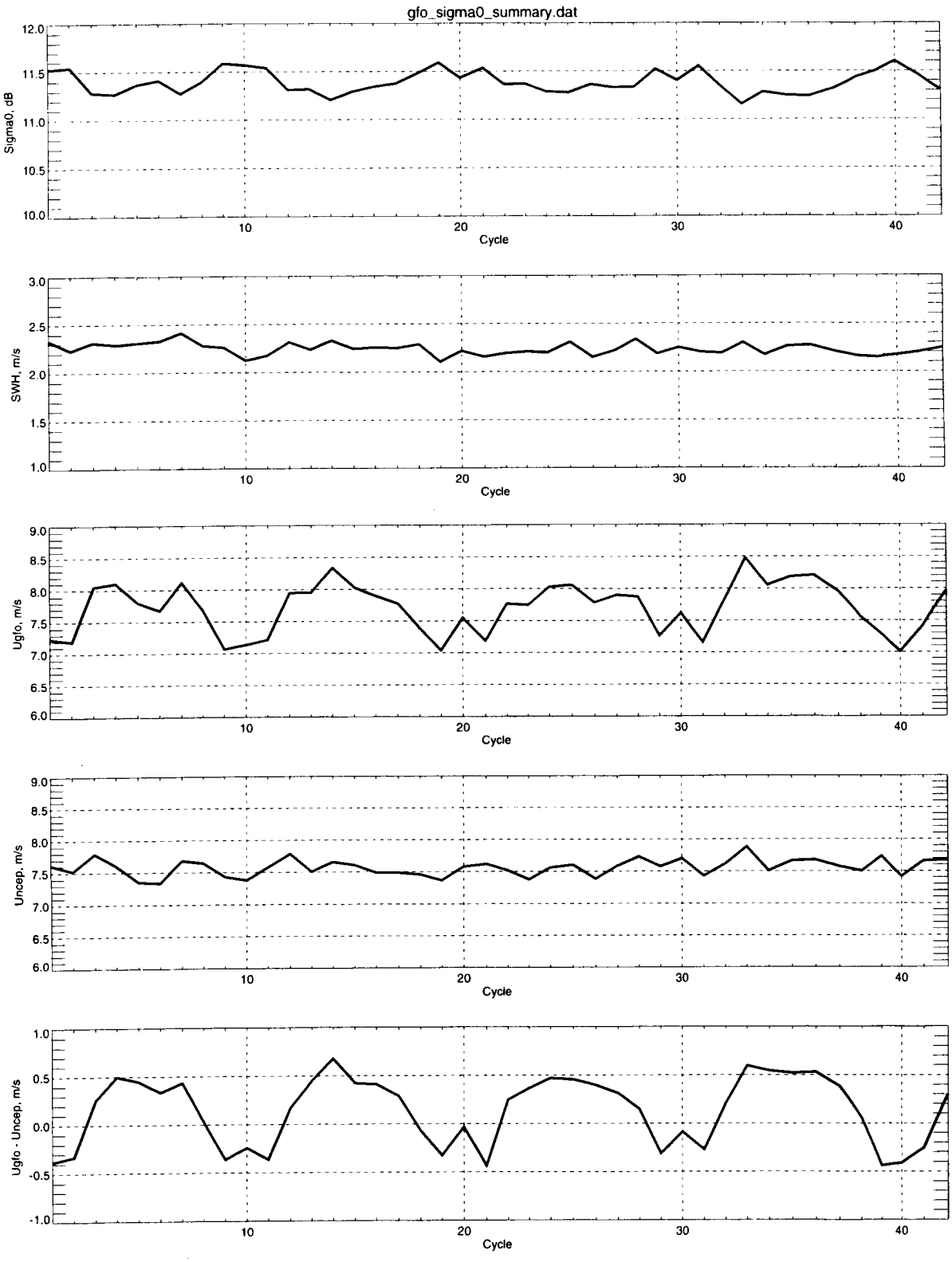

Figure 4-1 Plot of Selected Statistical Indicators from Table 4-1

4.2 Ice-Sheet Measurement Precision from Groundtrack Crossovers

The precision of the GFO ice sheet measurements may be calculated using crossover elevation differences. A crossover occurs when ascending and descending orbital groundtracks pass over the same geographic location, providing two separate measurements of the elevation at different times. Since ice sheet elevations change due to accumulation, flow, melting, and density changes, we calculate the precision using only crossovers that occur within 30 days of each other.

Groundtrack coverage of Antarctica and Greenland during the month of August 2001 is depicted in Figure 4-2 and Figure 4-3, respectively. The GFO crossover differences for that month have a standard deviation of 52 cm. The over-ice measurement precision results are discussed in "GFO NASA/GSFC Polar Ice Data Processing and Validation Report" published by Anita Brenner, et al, in December 21,2001.This report may be viewed at http://icesat4.gsfc.nasa.gov/ia_home/gfo_cal_val.html.

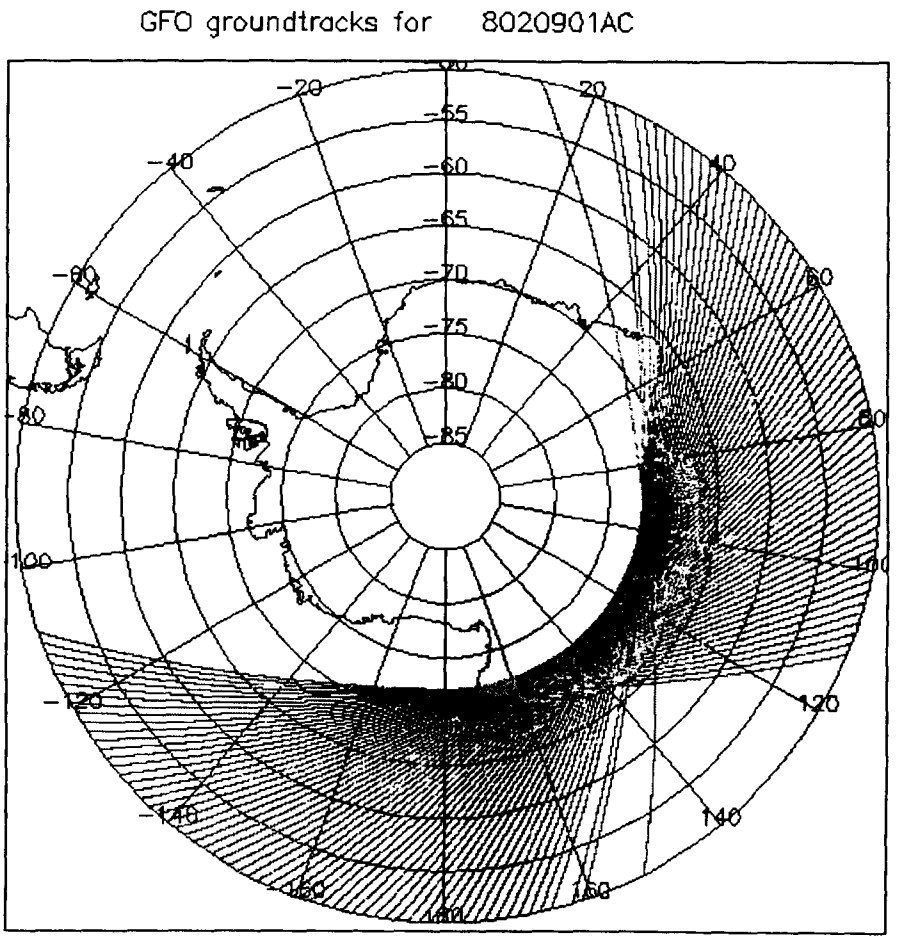

Figure 4-2 GFO Groundtracks over Antarctica during August 2001

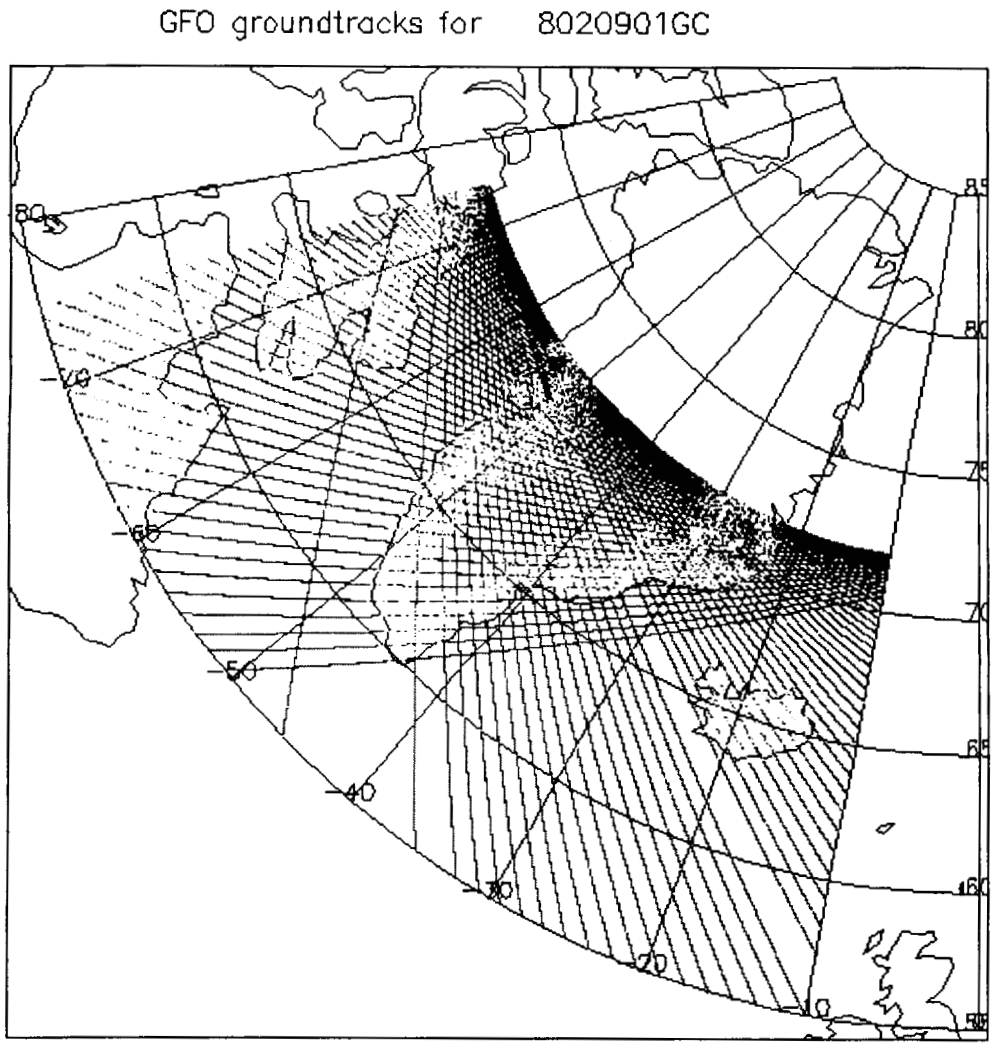

Figure 4-3 GFO Groundtracks over Greenland during August 2001

In the following figures of crossover statistics, the crossover RMS is shown for the different combinations of ice and ocean using POE and MOE orbits.

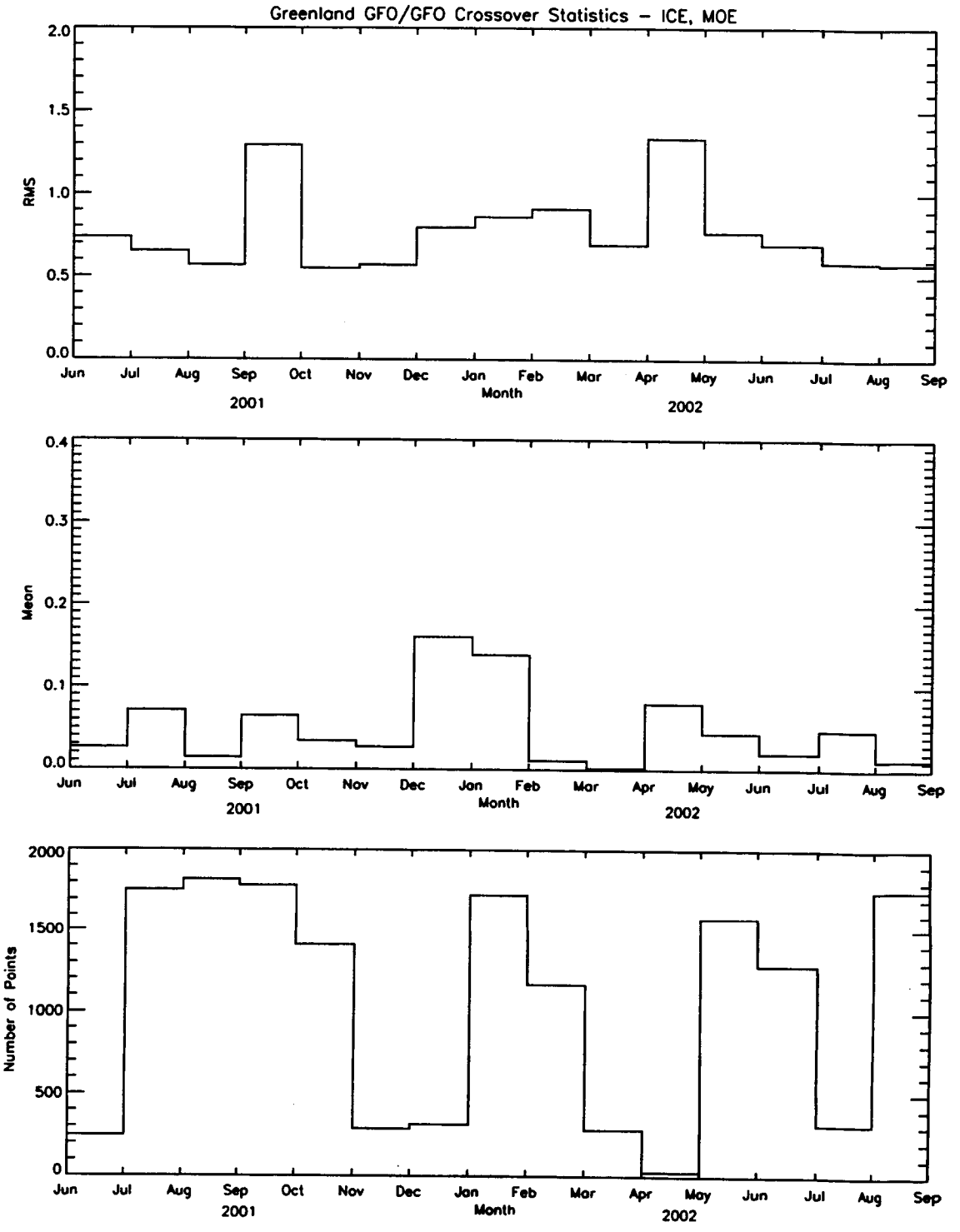

Figure 4-4 Greenland GFO/GFO Crossover Statistics - ICE, MOE

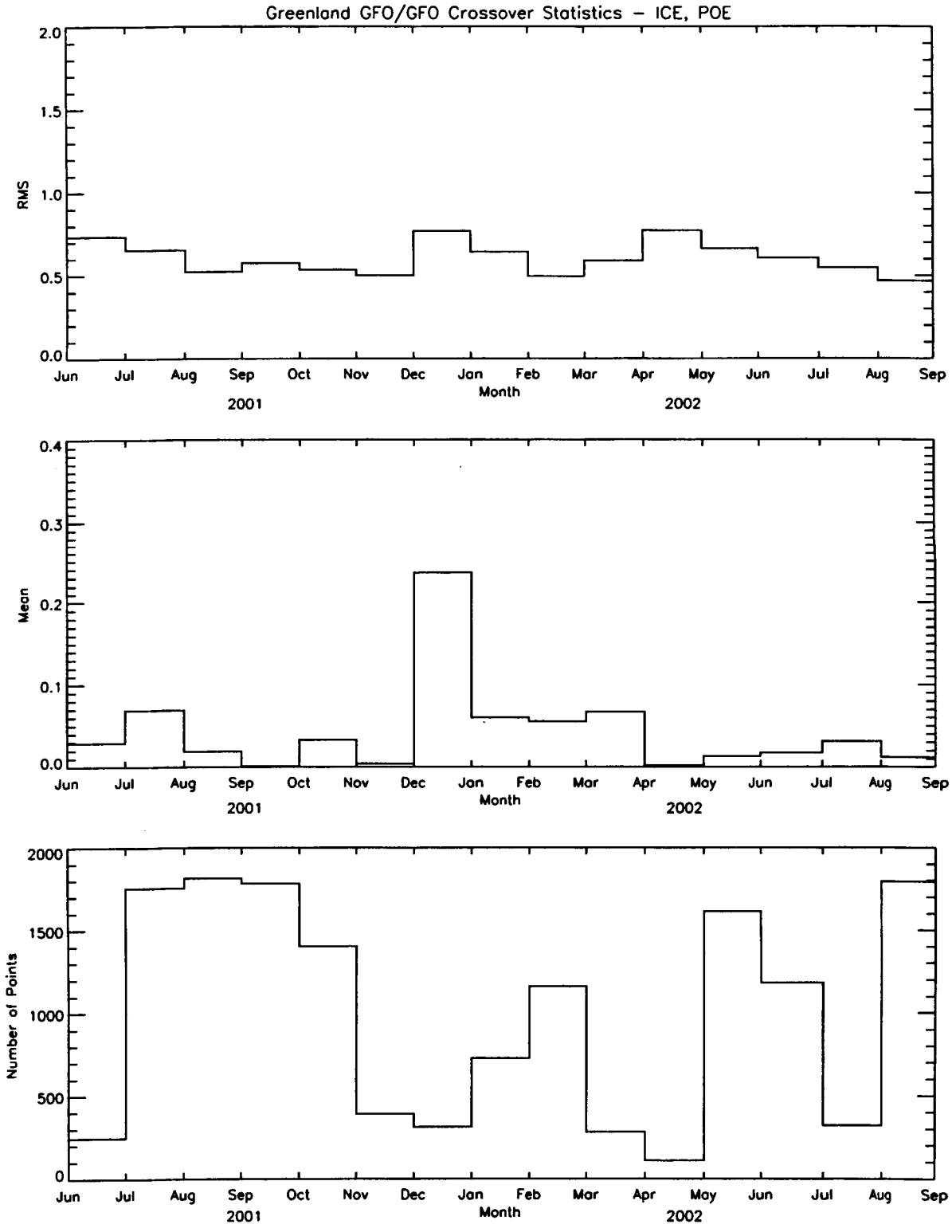

Figure 4-5 Greenland GFO/GFO Crossover Statistics - ICE, POE

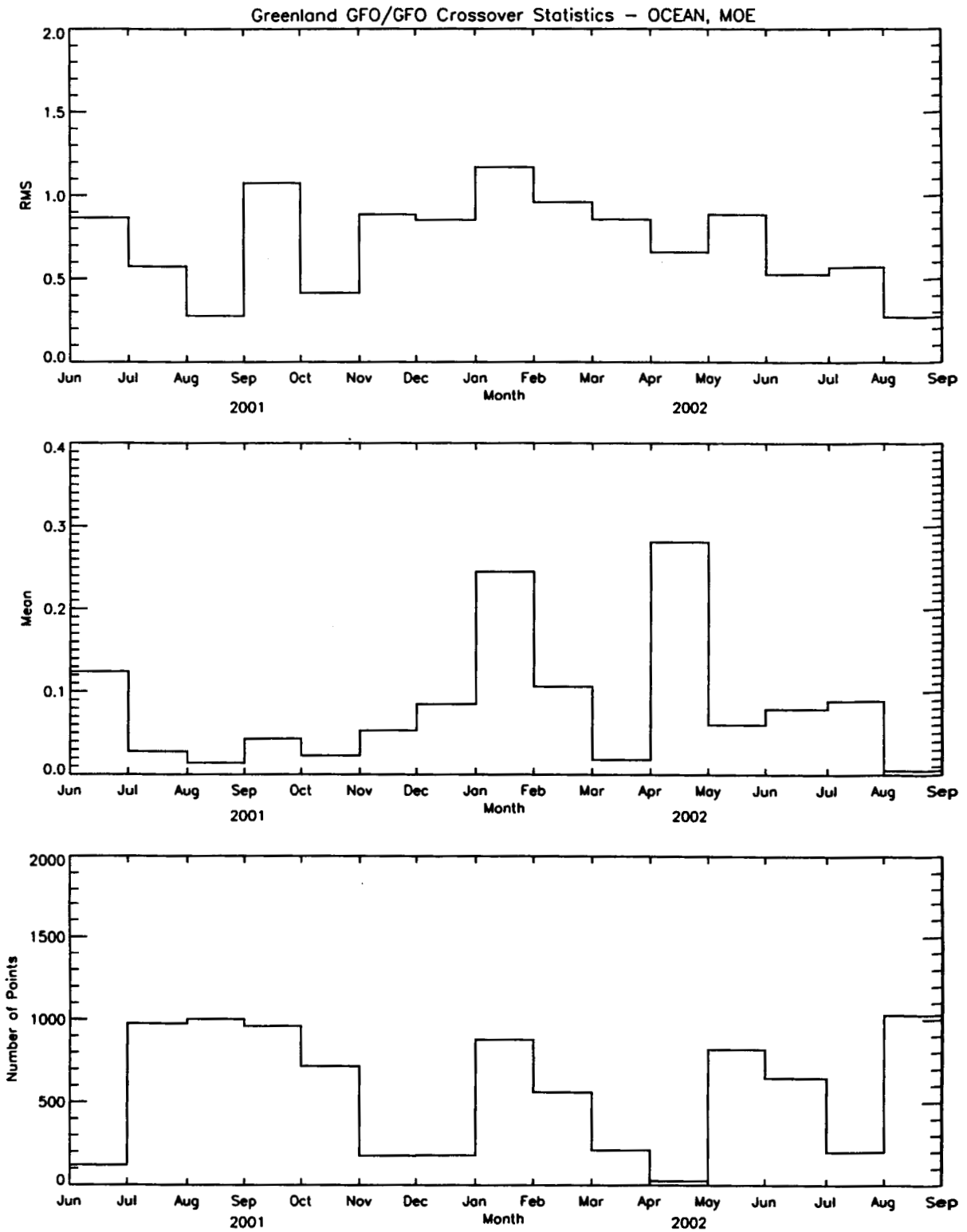

Figure 4-6 Greenland GFO/GFO Crossover Statistics - OCEAN, MOE

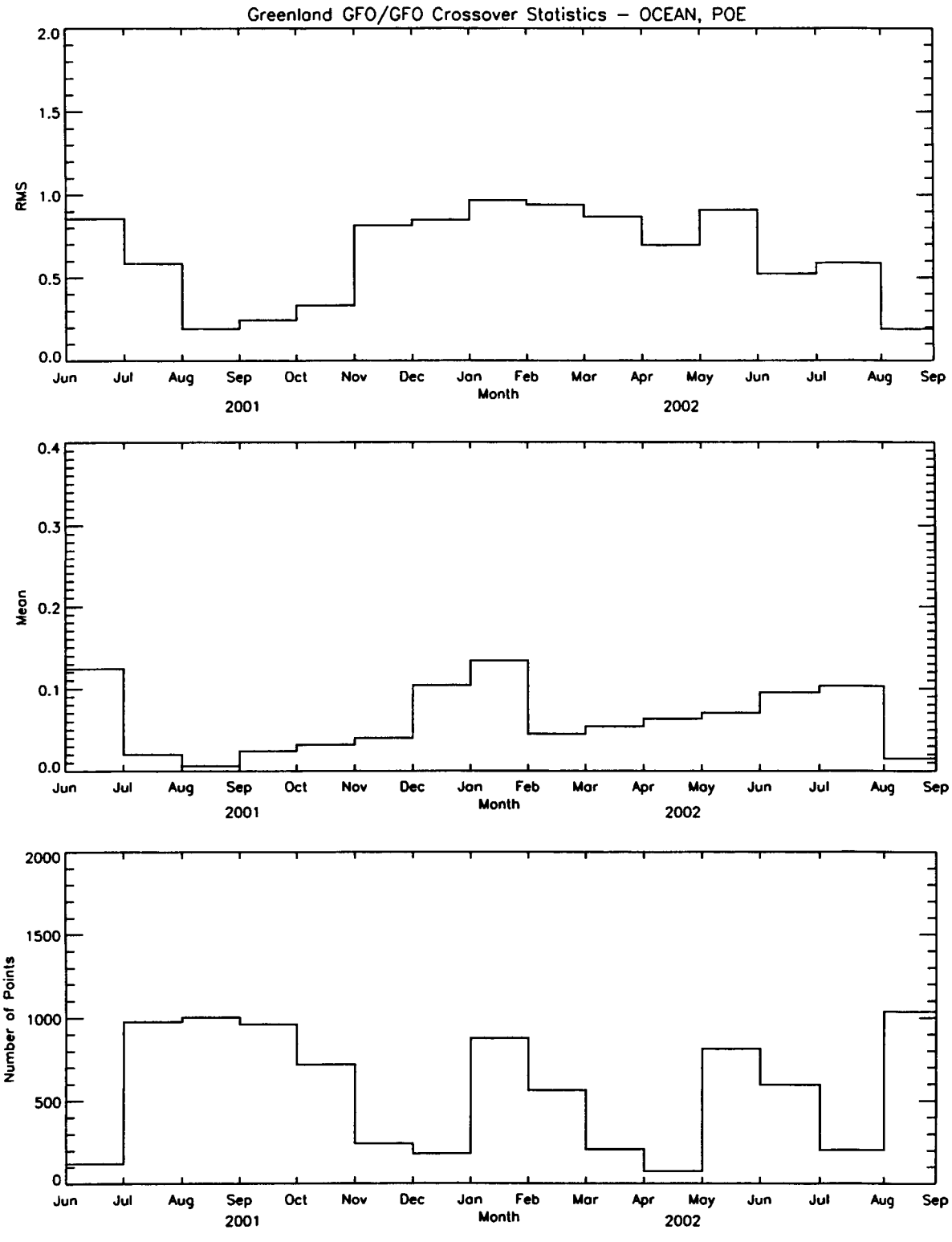

Figure 4-7 Greenland GFO/GFO Crossover Statistics - OCEAN, POE

4.3 Altimeter Boresight Calibration Maneuvers

For spacecraft-borne radar altimeters it is useful to perform an attitude bias calibration maneuver (ABCAL) to ensure that the spacecraft's attitude control system's nadir axis is correctly aligned with the altimeter's antenna axis. In 2002 there was an ABCAL performed for GFO on these dates: March 05 (2002 day 064), June 18 (2002 day 169), and November 13 (2002 day 317).

The spacecraft attitude control system normally maintains near-nadir pointing. In a GFO ABCAL, the spacecraft attitude control system is programmed to: 1) point off-nadir by about 0.6 degrees in the +X direction, 2) return to nadir pointing, 3) point off-nadir by about 0.6 degrees in the -X direction, 4) return to nadir, 5) point off-nadir by about 0.6 degrees in the +Y direction, 6) return to nadir, 7) point off-nadir by about 0.6 degrees in the -Y direction, and 8) return to nadir. The dwell time at each of the four off-nadir angles is of the order of 100 seconds, and the time at nadir between each off-nadir excursion is also of the order of 100 seconds. Additional time is used in the eight transitions from one attitude to another within the ABCAL, so the duration of the entire GFO ABCAL is approximately 900 seconds as shown in Figure 4-8.

For data analysis of an ABCAL, the altimeter's waveform-derived attitude estimates are compared with the estimates from the spacecraft attitude control system. We have used 2-second GFO waveform averages in waveform fitting to obtain the waveform-derived attitude estimates. Notice that the normal GFO data product's attitude estimates cannot be used for the ABCAL analysis because of the heavy Vatt smoothing in the normal GFO data processing. An example is provided in Figure 4-8 which shows

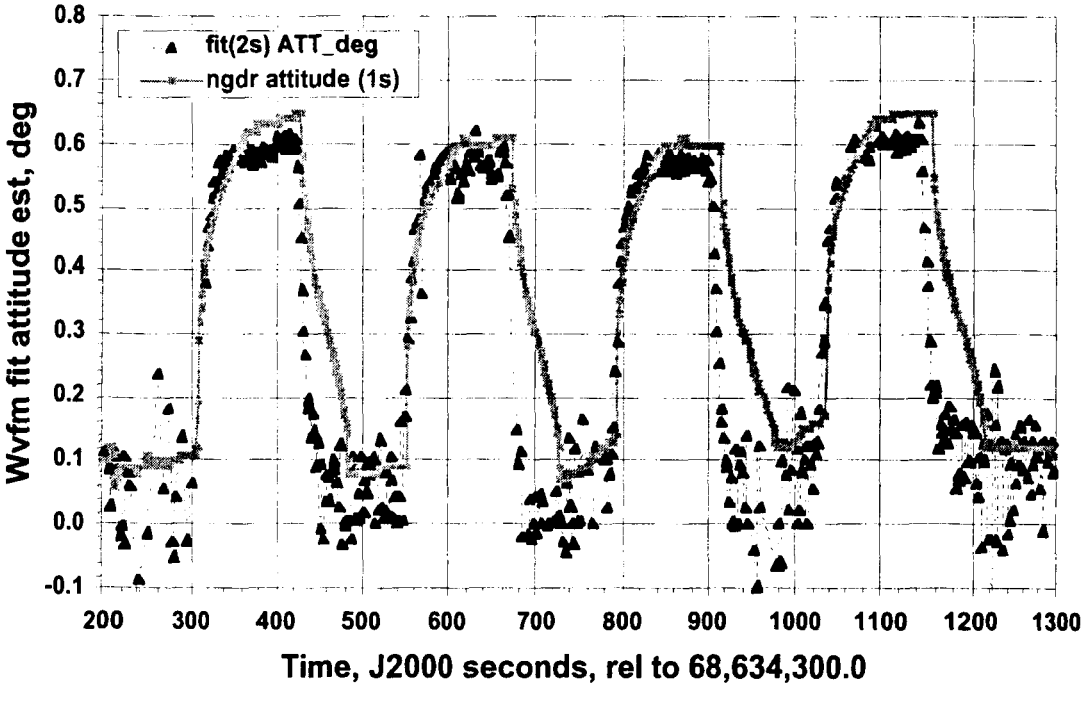

Figure 4-8 GFO Waveform Fit Attitude and NGDR Attitude in 05 March 2002 ABCAL:

the 2-second waveform fit attitudes and the GFO GDR attitudes plotted vs. time in the March 2002 ABCAL. This figure does, however, indicate that the spacecraft nadir axis and the altimeter antenna axis must be in good agreement, because the four attitude excursions are very close in magnitude. The altimeter waveform can provide only the magnitude of the off-nadir angle, and the few negative attitude estimates in Figure 4-8 are only a noise artifact and can be ignored.

For all three ABCALs in 2002, one-second averages of the spacecraft attitude control system data were supplied to us by Mike Weiss of Ball Aerospace & Technologies Corp. and in return we provided our waveform fit attitude estimates and boresight vector estimates to Weiss. Figure 4-9, Figure 4-10 and Figure 4-11 show summary data comparisons for the three GFO ABCALs in year 2002. All three ABCALs showed that

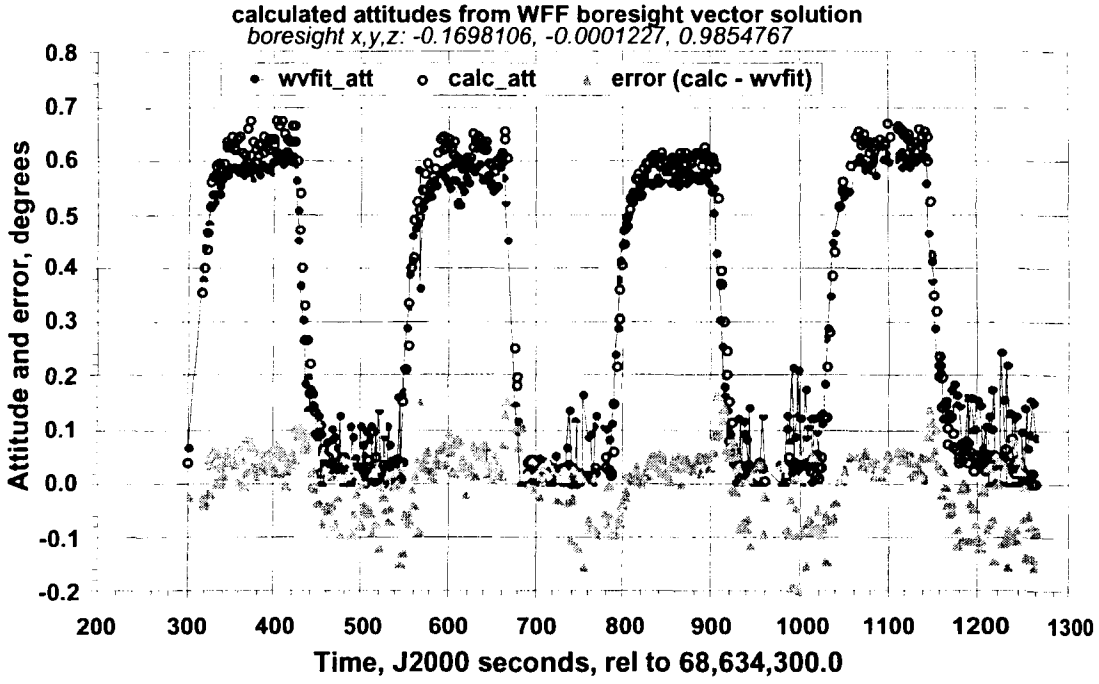

Figure 4-9 Waveform Fit and Calculated Attitudes in 05 March 2002 ABCAL

the spacecraft attitude control system's nadir vector was in good agreement with the altimeter antenna's boresight vector. While the boresight vector components varied slightly for these ABCALs, no further adjustment of the spacecraft control system's offsets seemed needed or advisable. For the TOPEX radar altimeter an ABCAL is performed once every half year, and six months would also be an appropriate GFO ABCAL spacing.

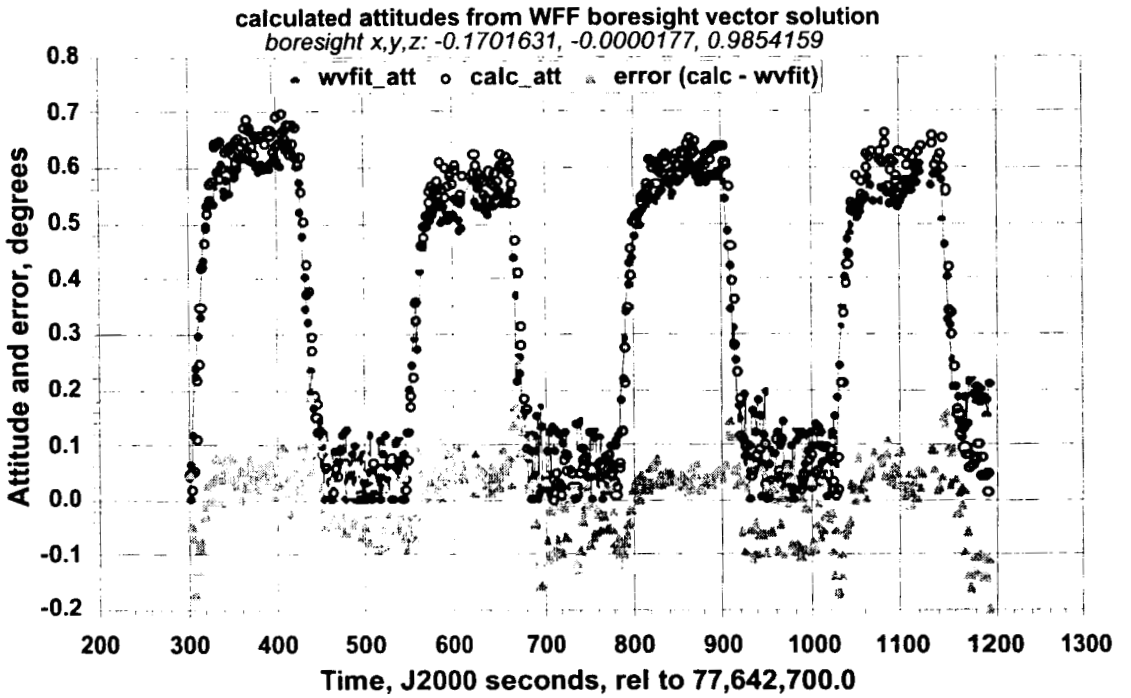

Figure 4-10 Waveform Fit and Calculated Attitudes in 18 June 2002 ABCAL

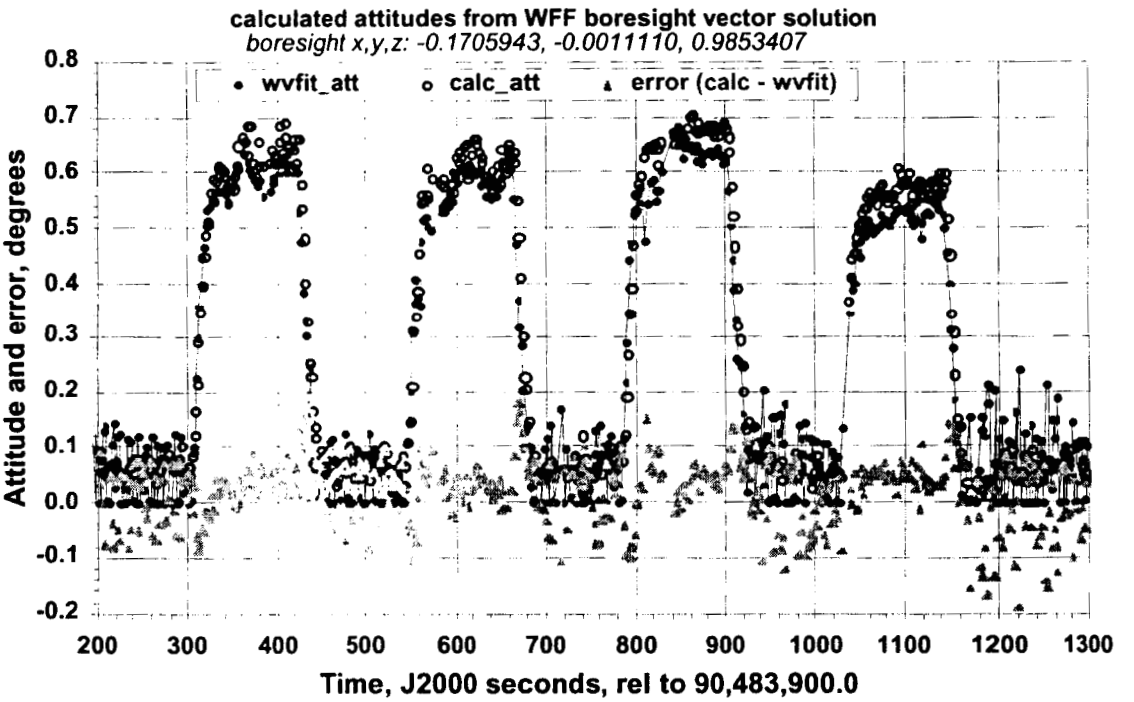

Figure 4-11 Waveform Fit and Calculated Attitudes in 13 November 2002 ABCAL

4.4 Discussion of GFO Flags and Low SWH in Cycle 35

4.4.1 Introduction and Summary

After J. McMillan reported an apparently unusual amount of data missing from track crossing points in GFO cycle 35, we have looked in some detail at some of the problem areas. There were two different classes of behavior reported: 1) some several relatively long GFO ground track segments having an unusually high percentage of several data flags set, and 2) some passes in local regions such as the Gulf of Mexico which had the SWH bounds flag set. Our conclusion was: 1) the long track segment data flags appeared during periods of known high telemetry bit error rates, so that the data flagging was normal and proper; and 2) the Gulf of Mexico SWH bounds flag was the result of unusually low real SWH, and that the SWH bounds may be excluding unusually low but real SWH values. The GFO behavior and these conclusions will be discussed in more detail in the following sections.

4.4.2 Long Track Segments Having High Percentage of Data Flags Set

We examined a number of these, and we found a large amount of various parameters flagged. After correlating this behavior with our WFF data logs, we have determined that these result from periods of high telemetry bit error rate induced at the ground stations. For the conditions of the data, the flagging is working and appears to properly eliminate the bad data, but there remain some oddities in the final NGDR that we do not understand.

As a specific example we will discuss a 2002 day 204 segment from (J2K) times 80,708,941 to 80,709,149 seconds. This segment goes from approximately 151.0 longitude, 43.1 latitude to 144.0 longitude, 31.8 latitude (longitude and latitude in degrees), and the water depth is greater than 4500 meters for this entire ~209 second segment. The following observations are from the NGDR data for this defined segment portion.

There is a probable Sigma0 bloom occurring about 56 seconds after the start of this segment and persisting for about 60 seconds. The fitted Vatt values are apparently good and the Vatt estimation error flag is zero for the entire segment. The SWH values increased, relatively monotonically, from 1.8 m at the start of the segment to 5.5 m at the end of the segment.

The SWH bounds error flag is set to 1 for 79 of the 212 records in this segment. Whenever the SWH bounds error flag is 1, the height bounds error flag and the AGC bounds error flags are also set to 1 and the leftmost 10 bits of the altimeter quality word indicate that one or more of the 10 subframe values is missing. Or put another way, whenever the quality word leftmost 10 bits have a value other than 0000000000, the SWH bounds error flag, the height bounds error flag, and the AGC bounds error flag are always 1. There are no cases in which these three flags have values different from each other.

In 21 of the 212 records in this segment there are default (error) values in: 1) uncorrected sea surface height; 2) corrected sea surface height; 3) EM bias; and 4) standard deviation of the uncorrected sea surface height. In all but one of these 21 records

there are also default values in the AGC and the standard deviation of the AGC. Of the 20 records in which there is a default value in the AGC, 7 records have default values in the Sigma0 as well but 13 records have reasonable real Sigma0 values. It's puzzling how a good Sigma0 value can be associated with a bad AGC value. There are two other records in this segment which have default values in some fields but not in the sea surface heights (both uncorrected and corrected) and the EM bias.

There were several records which had other default values than the combinations described in the preceding paragraph. The SWH bounds error flag was 1 at every one of the 21 records having default values in sea surface heights and EM bias. Since there were 79 records having the SWH bounds error flag set, this leaves more than 50 records in which the SWH bounds error flag was set but there were not default values in any of the other data fields. All the NGDR SWH values were 1.4 m or greater in the segment discussed, and only 20 of these had the default (655.35 m) value.

4.4.3 Gulf of Mexico Segments Having SWH Bounds Error Flag Set

We have looked at several GFO passes traversing the Gulf of Mexico, and find that there are a number of cases in which the SWH bounds flag is set but, contrary to the example in the preceding section, the height error bounds flag and the AGC bounds error flag are not set. These cases appear associated with low SWH values. The GFO SWH comes from a look-up table within the altimeter, and this table of SWH vs. Vswh can put out discrete, not continuous, SWH values. We have examined GFO raw telemetry data and found that lowest three SWH values are 0.0, 0.15, and 0.32 m, and that both the 0.0 and the 0.15 m values generally result in the default 655.35 SWH value in the NGDR.

Some of these passes have been in the RA Long mode, meaning that GFO waveform data are available, and for a couple of these segments we have fitted a model waveform function to 1-second averages of the waveform data. We will discuss specific results from two of these low-SWH Gulf of Mexico passes.

For a 2002 day 221 GFO pass there are about 150 records over water deeper than 100 meters; the first time of this small segment is about 82,152,195 seconds (J2K). For all but two of the 150 records, the altimeter is in normal EML fine track with power estimation from the AGC gate. There is a relatively high Sigma0 value, a potential Sigma0 bloom condition, in the first 1/3 of this segment. The Vatt estimation error flag is 1 for the first 77 records, then zero for the remainder. For this segment there are only 9 records in which the SWH bounds flag is not 1, but there are 18 records with non-default values for SWH. Most of these non-default SWH values are less than 0.5 m. Waveform fits to 1-second averages were done for this segment with good fit results for almost all, and nearly all the fitted 1-second SWH values were between 0 and 0.6 m. The GFO waveform averages all appeared quite normal. We also examined some TOPEX altimeter data from a pass close in time and location to this 2002 day 221 GFO pass, and the TOPEX data also have very low SWH values.

Another low-SWH segment was examined from 2001 day 228; this has the same ground track as the 2002 day 221 GFO pass just discussed, and the time separation of the two segments is about a year. The 2001 day 228 segment has about 150 records

over water deeper than 100 meters, starting at time 51,215,627 seconds, and all these records show normal EML fine track with power estimation from the AGC gate. The GFO Sigma0 values are less than 13.1 dB for all records in the segment. The Vatt estimation flag is set for only the first 10 records, and is 0 for all other records. Late in the segment there are a couple of instances of the rate error flag's being set to 1. Otherwise there are no flags set except for the SWH bounds flag which is set for 10 of the records in the segment. Default values appear in the SWH for only 4 of the segment's records. Waveform fits to the 1-second averages from this show SWH values ranging from about 0.4 to 0.8 m, and these waveform fit SWH values are on average about 0.15 or 0.2 m higher than the GFO SWH values.

4.4.4 Discussion

The SWH bounds flag has apparently different behavior in the longer pass segment (2002 day 204) than in the two Gulf of Mexico segments discussed. In the longer segment, the SWH bounds flag was 1:1 correlated with the height bounds flag, the AGC bounds flag, and with one or more subframes of data missing. This longer segment behavior is apparently the result of data errors which were known to be occurring around this time in GFO.

The Gulf of Mexico segments seem to be a real effect of unusually low surface SWH. The 2002 day 221 GFO segment had many more SWH bounds flags set and many more default SWH values than did the 2001 day 228 segment; the waveform fit SWH values for 2002 day 221 were also slightly less than the waveform fit SWH values for 2001 day 228. The SWH out of the GFO altimeter comes from a table look-up for an on-board SWH vs. Vswh table, and for the year 2002 Gulf of Mexico segments the altimeter may be returning the lowest possible value from the (quantized) on-board table. From the web document "SDR Format, Content, and Algorithms", available at http://gfo.bmpcoe.org/Gfo/Data_val/Cal_formats/sdr_format.htm, the altimeter limits table includes the following values:

agc_upper_bound = 64.0

agc_lower_bound = 0.1

hgt_upper_bound = 825.0 km

hgt_lower_bound = 775.0 km

swh_lower_bound = 0.01 m

swh_upper_bound = 20.00 m

There is not enough information in this web document to understand how these bounds are applied in the data processing. To fully explain the observed SWH error bounds flag behavior, we would need to get more detailed GFO algorithm/processing descriptions and would also need the values from the current GFO on-board SWH look-up table.

Our overall conclusion is that the GFO radar altimeter appears to continue performing well. The additional flagging in 2002 Gulf of Mexico data appears to be the result

of zero or near-zero GFO SWH values which are being flagged in the NGDR processing. We think that there have been relatively more low SWH values in the Gulf of Mexico this year than in previous years, and that the GFO higher flagging is the result of this real surface change rather than any change or drift in the GFO altimeter's characteristics.

Section 5

WFF's Recommendation to GFO Project

5.1 Attitude Adjustment

The WFF team recommended an attitude adjustment based on our analysis of a December 2001 ABCAL. See Appendix B for comments and analysis. This bias was uploaded on 26 February 2002. See Section 4.3 for discussion of the three ABCALs conducted in 2002. See Section 3.3.2 for results.

5.2 SWH Bounds Limit

The GFO SWH is low by about 0.24 meters as reported in the "GFO Altimeter Engineering Report, From Launch to Acceptance". Beginning in the early part of 2002, there has been an increase in the occurrence rate of SWH bounds error flags. We recommend that the 0.24 meter bias be added to the GFO SWH or change the lower limited SWH bounds. The lower limit of the SWH was changed and became the operational value on 29 October 2002.

Section 6

Engineering Assessment Synopsis

6.1 Performance Overview

Our analyses of the GFO altimeter demonstrate that it is performing well. Its range measurement precision is comparable with contemporaneous satellite radar altimeters, including TOPEX. Its internal calibrations and its cycle-to-cycle global averages have been very consistent. Comparisons with other sensors indicate that measurement biases are within GFO's pre-flight specifications of: SWH +/- 0.5m, Sigma0 +/- 1 dB, and Windspeed +/- 2 m/s.

The GFO windspeed has been shown to have a small variation based on instrument temperature as discussed in Section 2.2.6.

During the assessment of the GFO altimeter performance, WFF has encountered a number of data problems that are the result of ground data processing errors. These processing errors are noted in Section 2.4.

The GFO SWH values are known to be low. In instances where SWH is above zero but very small, these data are getting flagged and causing processing to edit some data. See Section 5.2.

We are continuing our GFO altimeter performance assessment on a daily basis, and are continuing to develop improved analysis techniques. Supplemental performance reports will be issued on a regular basis, and special reports will be prepared as warranted.

Section 7

References

7.1 Supporting Documentation

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Appendix A
Cumulative Index of Studies

Great Lakes Study, *GFO Altimeter Engineering Assessment Report, The First 20 Cycles Since Acceptance*, NASA/TM-2002-209984/Ver.1/Vol.3, March 2002.

GFO Correction to Range for the Effects of Oscillator Drift, *GFO Altimeter Engineering Assessment Report, The First 20 Cycles Since Acceptance*, NASA/TM-2002-209984/Ver.1/Vol.3, March 2002.

AGC Trends for the First 17 GFO Cycles, *GFO Altimeter Engineering Assessment Report, The First 20 Cycles Since Acceptance*, NASA/TM-2002-209984/Ver.1/Vol.3, March 2002.

GFO Altimeter Wind Speed Monitoring, *GFO Altimeter Engineering Assessment Report, The First 20 Cycles Since Acceptance*, NASA/TM-2002-209984/Ver.1/Vol.3, March 2002.

GFO Altimeter Sigma0 and SWH Calibration Correction - *GFO Altimeter Engineering Assessment Report, From Launch to Acceptance*, NASA/TM-2001-209984/Ver.1/Vol.1, March 2001.

GFO "Smile Patch" and Its Consequences - *GFO Altimeter Engineering Assessment Report, From Launch to Acceptance*, NASA/TM-2001-209984/Ver.1/Vol.1, March 2001.

GFO Sigma0 and SWH Calibration Correction - *GFO Altimeter Engineering Assessment Report, From Launch to Acceptance*, NASA/TM-2001-209984/Ver.1/Vol.1, March 2001.

GFO Sigma0 Comparison of GFO and TOPEX - *GFO Altimeter Engineering Assessment Report, From Launch to Acceptance*, NASA/TM-2001-209984/Ver.1/Vol.1, March 2001.

GFO SWH Comparison of GFO and TOPEX - *GFO Altimeter Engineering Assessment Report, From Launch to Acceptance*, NASA/TM-2001-209984/Ver.1/Vol.1, March 2001.

GFO Range and SWH Consequences of Thermal Change - *GFO Altimeter Engineering Assessment Report, From Launch to Acceptance*, NASA/TM-2001-209984/Ver.1/Vol.1, March 2001.

Sigma0 Blooms and Examples in GFO Data - *GFO Altimeter Engineering Assessment Report, From Launch to Acceptance*, NASA/TM-2001-209984/Ver.1/Vol.1, March 2001.

Temperature Correction for AGC - *GFO Altimeter Engineering Assessment Report, From Launch to Acceptance*, NASA/TM-2001-209984/Ver.1/Vol.1, March 2001.

WFF Recommended Sigma0 and SWH Corrections - *GFO Altimeter Engineering Assessment Report, From Launch to Acceptance*, NASA/TM-2001-209984/Ver.1/Vol.1, March 2001.

Appendix B
WFF Comments on the GFO ABCAL

Comments on the GFO Attitude Calibration Maneuver (ABCAL)
of 20 December 2001, and its Data Analysis

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Introduction

In spaceborne radar altimeters it is useful to perform a controlled attitude variation, comparing the spacecraft attitude control system s attitude estimates with altimeter waveform-based attitude estimates. Data comparison from such an attitude bias calibration maneuver (ABCAL) can determine if there are systematic biases in the spacecraft control system s attitudes. For the TOPEX radar altimeter a cross-shaped ABCAL has been executed about once every six months through the life of the mission (the ABCALs were more frequent early in TOPEX when the attitude control system was still being tuned). In the past year it was decided that an appropriate ABCAL should be defined and performed for GFO.

Following discussions with the Ball Aerospace & Technologies Corporation (BATC), a GFO ABCAL sequence was specified as summarized in Attachment A of this memo. Basically this was a series of four maneuvers to roll and pitch the spacecraft a nominal –0.6 degrees. This GFO ABCAL was executed on 20 December 2001. The entire ABCAL took approximately 16 minutes, starting at +18.07 latitude, 249.64 longitude and ending at -65.84 latitude, 19.80 longitude.

All figures in this memo will plot data vs. time in seconds relative to 62,137,800 seconds in the J2000 time system. The value 62,137,800 seconds (J2000) is 16:30:00 GMT of 20 December 2001, and the GFO ABCAL began almost five minutes after that time. The BATC-supplied components of the GFO spacecraft s geodetic nadir unit vectors during the ABCAL are plotted in Figure B-1, Figure B-2, and Figure B-3.

GFO attitude estimates from waveform fitting

The general expression for a radar altimeter s mean return waveform has been described earlier, *e.g.*, Corrections for the effects of significant wave height and attitude on Geosat radar altimeter measurements , G.S. Hayne and D.W. Hancock III, J. Geophys. Res., Vol. 95 (No. C3), pp 2837-2842, March, 1990. We used a general nonlinear least squares method to fit 2-

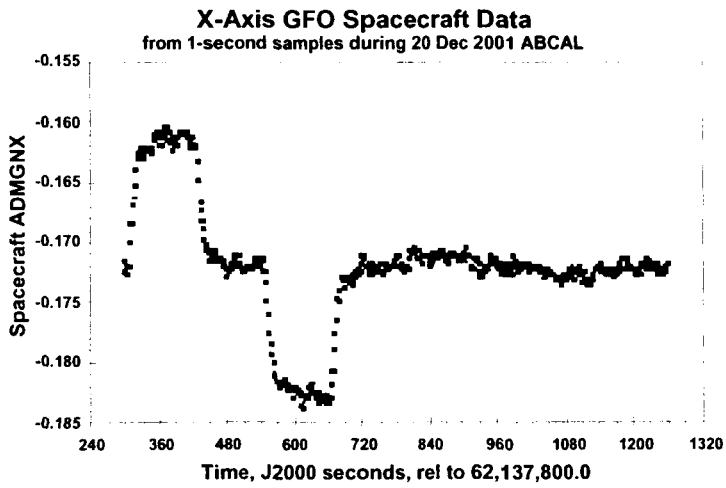

Figure B-1 Spacecraft X Component

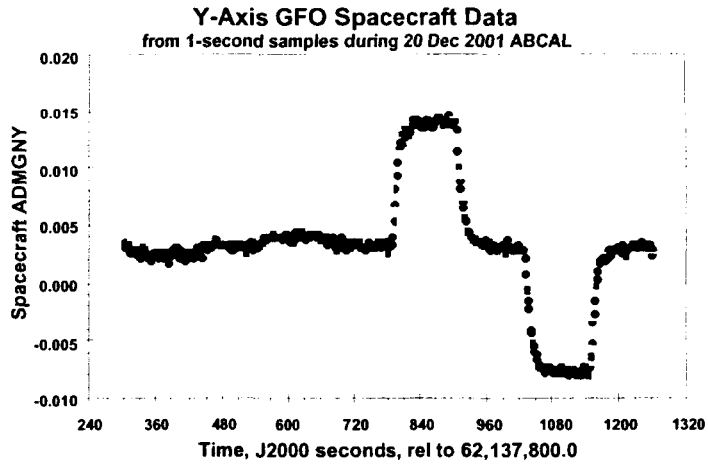

Figure B-2 Spacecraft Y Component

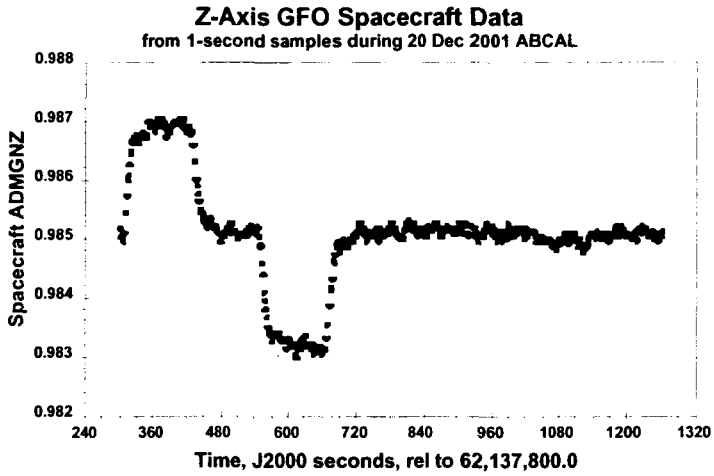

Figure B-3 Spacecraft Z Component

second averaged waveform data to this general altimeter function by varying five fit parameters: amplitude, range, significant waveheight (SWH), baseline, and attitude. The fit was performed for fixed surface skewness of 0.0, assuming a fixed altitude of 800 kilometers and a GFO antenna beamwidth of 1.60 degrees. Several data points were deleted because of failure of the fit to converge properly, and additional data were deleted because the gate index changed within the 2-second averages, but fewer than 20 data points were eliminated within the time range of the geodetic nadir unit vectors from BATC, leaving 466 2-second good waveform fit attitude estimates within this time range.

Figure B-4 shows the GFO attitude estimates from the waveform fitting of the 2-second waveform averages. The attitude estimates from the GFO processing are also shown in Figure B-4, labeled as ngdr attitude (1s). These latter ngdr attitude estimates are **not** suitable for use in estimating a new boresight vector, because in GFO s GDR data processing there is very heavy filtering of the quantity V_{att} which is the attitude-related voltage from which the attitude is estimated. Only the waveform-fit-estimated attitudes are suitable for this purpose, because these estimates are effectively independent and uncorrelated.

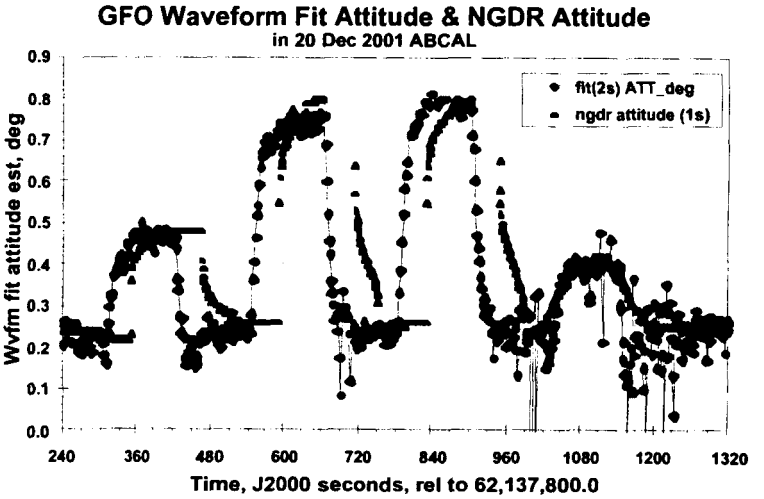

Figure B-4 GFO Attitude Estimates

It s also worth checking the SWH estimates from the waveform fitting, and these are plotted in Figure B-5 together with the estimates from the GFO ngdr. Finally Figure B-6 plots the fit rms differences between the input waveform sample averages and the fitted waveform function. Figure B-6. For near nadir pointing the waveform fit amplitudes are 1200 or so, so these fit rms values are a very small fraction of the waveform s amplitude. Figure B-5 and Figure B-6 are basically sanity checks indicating that the attitude data of Figure B-4 should be relatively reliable.

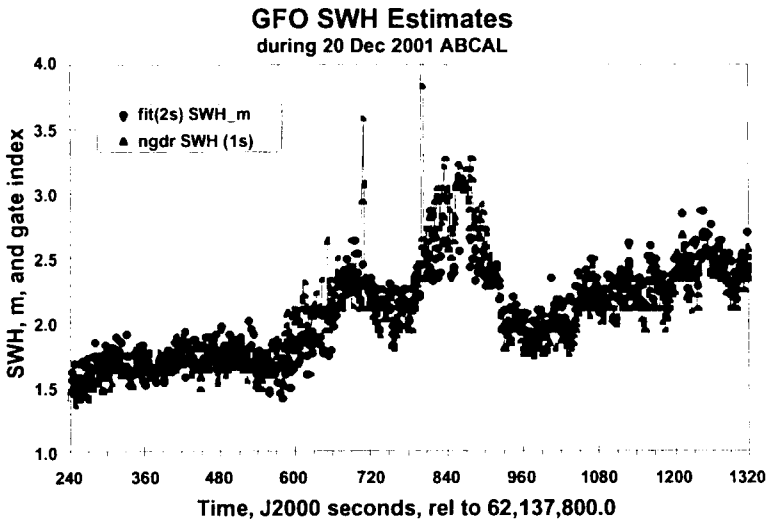

Figure B-5 GFO SWH Estimates

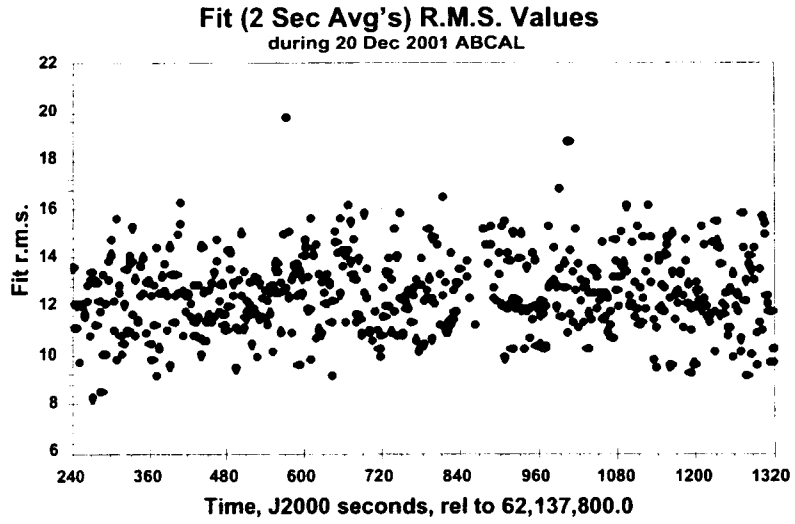

Figure B-6 Waveform Fit RMS Errors

Obtaining new boresight vector estimates from ABCAL data

Quoting directly from a memo EXAMPLE GFO BORESIGHT CALIBRATION , by Doug Wiemer, Ball Aerospace & Technologies Corp., 20 October 2001, ... the boresight vector is computed using the following least-squares method:

Boresight_Vector = pinv(Body_Frame_GD_Nadir) * cos(Offsets) (1)

in which

Boresight_Vector is a 3x1 unit-vector defining the best estimate of where the altimeter boresight is in the body frame,

Body_Frame_GD_Nadir is an nx3 matrix containing all the body-frame geodetic nadir unit-vectors measured over the maneuver test interval,

Offsets is an nx1 vector containing all of the corresponding measured boresight offsets from geodetic nadir determined from altimeter data, and

pinv is Matlab s pseudo-inverse function; pinv(N) is equivalent to $(N^{*}N)^{-1}{*}N$ for well conditioned matrices.

Equation (1) is based on the vector dot-product relationship:

cos(Offsets) = Body_Frame_GD_Nadir • Boresight_Vector . (2)

I implemented Wiemer s equation (1) by writing an IDL procedure Interp_AbCal_Data which is printed in Attachment B. This procedure uses singular value decomposition in solving Wiemer s equation (1); see *Numerical Recipes in Fortran 77, The Art of Scientific Computing, Second Edition*, by W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Cambridge University Press, 1992 - in particular Section 2.6 discussion of SVD for more equations than unknowns, and the Chapter 15 discussion of the least-squares solution to an overdetermined set of linear equations.

For times within the December 2001 GFO ABCAL, BATC supplied us with the spacecraft attitude control system s 1-second estimates of **Body_Frame_GD_Nadir**. These data are plotted in Figure B-1, Figure B-2, and Figure B-3. The WFF 2-second waveform fit attitude estimates, plotted in Figure 4 (labeled as fit(2s) ATT_deg in that figure), provided the quantity **Offsets** for Wiemer s equation (1). Spline interpolation is used within Interp_AbCal_Data to select **Body_Frame_GD_Nadir** values at the same times as the **Offsets** estimates. Each of the 1-second estimates in **Body_Frame_GD_Nadir** was supposed to be a unit vector, but the magnitudes (i.e., the square root of the sum of the squares of the x, y, and z components) varied slightly second-to-second, so each of the interpolated **Body_Frame_GD_Nadir** estimates was renormalized to unit magnitude within Interp_AbCal_Data before solving for **Boresight_Vector**.

The result from Interp_AbCal_Data for 466 2-second waveform-fit-estimated attitudes through the ABCAL time, was that the new **Boresight_Vector** x, y, and z estimates were:

0.1699464, -0.0002839, and 0.9854533.

From Wiemer s equation (2), once the new **Boresight_Vector** is obtained a new set of **Offsets_calc** can be found as

Offsets_calc = Arccos (Body_Frame_GD_Nadir ¥ Boresight_Vector)

These Offsets_calc are plotted in Figure B-7 (labeled as calc_att in that figure) and compared with the waveform-fit-estimated attitudes **Offsets** (labeled as wvfit_att in the figure). The

errors (calc_att - wvfit_att) are also plotted in Figure B-7, and for these errors the mean difference was 0.027 degrees and the standard deviation was 0.051 degrees.

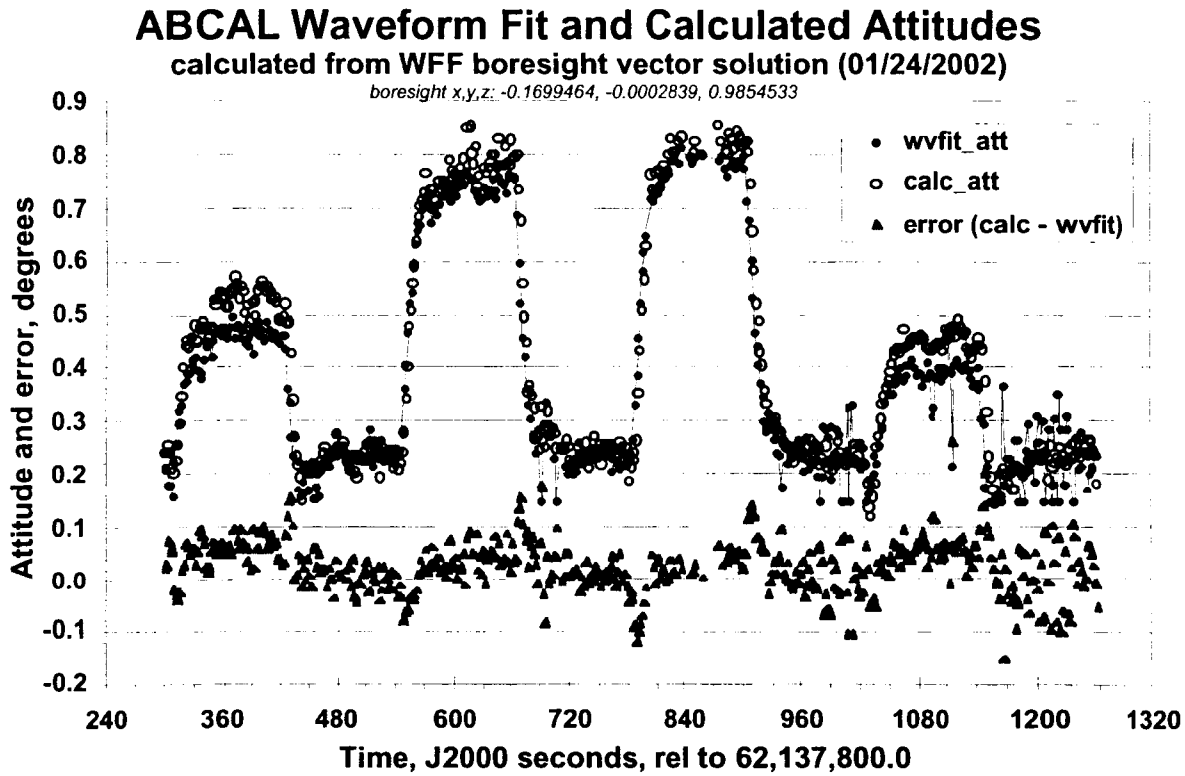

Figure B-7 Comparison of Waveform Fit Attitudes and Attitudes Calculated from New Spacecraft Boresight Vector Solution

The old boresight vector currently in the GFO flight software tables has x, y, z values:

- 0.1715230, 0.0031832, and 0.9851750.

The arccos of the dot product of the old and the new boresight vectors gives the angle difference between old and new boresight, and this difference is 0.218 degrees.

We had supplied our GFO ABCAL 2-second waveform-fit attitude estimates to BATC, and they found new **Boresight_Vector** values very similar to ours and having comparable mean and standard deviation values for the attitude estimate differences. BATC results are summarized in GFO Boresight Calibration (ABCAL - December 20, 2001) , by Matthew Verbeke, Ball Aerospace & Technologies Corporation Systems Engineering Report No. SP0025-ADC-059, 30 January 2002. Figure 1 of this report corresponds very well with my Figure 7 (where I have used the same plot symbols and colors to assist the comparison). The BATC report also gives the values for the new body to control frame quaternion resulting from the new boresight estimate.

Summary and Conclusion

In discussions with the Ball Aerospace & Technologies Corporation (BATC) an attitude bias calibration maneuver (ABCAL) for GFO was specified and was executed on 20 December

2001. We produced GFO attitude estimates through the ABCAL by waveform fitting, and sent to BATC a copy of these attitude estimates. BATC supplied us with GFO attitude control system estimates of body frame geodetic nadir unit vectors over the maneuver period. This memo has described the WFF waveform fitting, and has summarized the BATC method of estimating the boresight vector. From the ABCAL data both BATC and WFF produced comparable estimates of the boresight vector; these estimates indicate an off-nadir attitude bias of about 0.2 degrees for the current GFO configuration. BATC has produced values for the new body to control frame quaternion which would remove this attitude bias. Now it is time to decide if these new quaternion values should be implemented.

Attachment A
Part of an email message from George Hayne to Mike Weiss on 10/24/2001.

In a previous email I had described the TOPEX attitude bias calibration maneuver (ABCAL). Then I extrapolated from the TOPEX ABCAL to a proposed GFO ABCAL. You suggested that GFO maneuvers too quickly to provide the profile I suggested, but I think we're in pretty good shape anyhow. The GFO slew rates are higher than I might have wished, but there would be useful information to be gained even in the limiting case of a square-wave-looking attitude vs. time.

I think we could get some reasonable attitude estimates from 1-second waveform averages in the 0.7 degree pitch maneuver shown in Doug's Figure 1, and certainly from the last couple of tens of seconds in this example. There is the possibility that the overshoot in angle would cause the altimeter to lose lock, but it would acquire track again within 5 seconds or so as the angle came back to 0.7 degrees from its overshoot. I had originally proposed 0.7 degrees as the angle excursion, but I think that we would get good enough data from 0.6 degree attitude excursions, and this choice would reduce the time that the tracker might be out of lock because of the attitude. A reasonable proposal would be to allocate 120 seconds for each of the steps in a cruciate ABCAL; this would give enough time for track acquisition even if the track were to be lost at the attitude extremes. Here is a proposed GFO ABCAL sequence in pitch and roll (in degrees), and T_{start} and T_{finish} are the start and finish times of each segment in seconds.

Seg-ment	T_{start}	T_{finish}	X_{start}	Y_{start}	X_{finish}	Y_{finish}
1a	0	120	0	0	+0.6	0
1b	120	240	+0.6	0	0	0
2a	240	360	0	0	-0.6	0
2b	360	480	-0.6	0	0	0
3a	480	600	0	0	0	+0.6
3b	600	720	0	+0.6	0	0
4a	720	840	0	0	0	-0.6
4b	840	960	0	-0.6	0	0

I refer to X and Y in this; one of these is pitch and one is roll, but I don't care at all which is which. This maneuver will give us several tens of seconds of data at each of the four extremes in pitch and roll. The entire sequence is completed within 960 seconds and has to be scheduled so that the entire 960 seconds is over-water, a not unreasonable time (the TOPEX ABCAL is 840 seconds, for example). As compared to TOPEX, this GFO ABCAL would give us faster attitude slew rates and relatively longer dwell times at the attitude extremes. This proposed

GFO ABCAL is a replacement for an earlier version I proposed; that earlier version should now be ignored.

Attachment B

IDL procedure Interp_AbCal_Data to perform the equivalent of Matlab s pseudo-inverse function, pinv, for computing the GFO boresight vector.

```
PRO Interp_AbCal_Data
;  filename interp_abcal_data.pro   gsh last rev 2002/01/24, 1400 hrs
;  G.S. Hayne       NASA/GSFC/WFF Code 972     2002/01/09
;
;  This version reads in two free-format text (tab-separated)
;  files produced from Excel in analyzing the December 2001 GFO
;  ABCAL. One file contains times and the spacecraft control system's
;  body frame estimates. The other file contains times and the
;  waveform-fit-estimated attitude angles. The output file contains
;  the times and attitudes from the waveform fit file, and the
;  values of the spacecraft body frame estimates interpolated to the
;  times of the waveform fit attitudes. This procedure produces
;  an estimate of the boresight vector calculated by the method
;  in Doug Wiemer's memo of 30 October 2001 (Ball Aerospace).
;
;  Significant changes (not including minor cosmetic mod's):
;  2002/02/24 - Added a renormalization step for the input spacecraft
;     unit vector estimates.
;  2002/01/10 - Wrote the initial version of this procedure, including
;     use of IDL library singular value decomposition routines
;     to estimate GFO boresight vector..
;
;  Calling list positional parameters:
;    none ---
;  Calling list keyword parameters:
;    none ---
;  Routines called:
;    none ---
;-------------------------------------------------------
;
;;... constants, etc. ....
 tb = String(09B)           ;  tab character
;
;;.... set up place holders for input data
 spacecraft_in = {               $
        trel     : Double(0) ,   $
        ax       : Double(0) ,   $
        ay       : Double(0) ,   $
        az       : Double(0) ,   $
        rxyz     : Double(0)    }
 spc = Replicate(spacecraft_in, 6000)   ; overestimate of space needed
 fit_att_in = {              $
        trel     : Double(0) ,   $
        att       : Double(0) ,  $
        cos      : Double(0)    }
 fit = Replicate(fit_att_in, 6000)   ; overestimate of space needed
 hdr_s = ' '      ; holds to-be-ignored spacecraft header line
 hdr_f = ' '      ; holds to-be-ignored fit attitude header line
;
;;....Open input spacecraft data text file from dialog
 fnami_s = Dialog_Pickfile(/Read, Filter = '*.txt',   $
        Title = 'Input File Name for Spacecraft Data' )
 Print, 'Opening File ',fnami_s
 OpenR, unit_s, fnami_s, /Get_Lun
;;....Open input fit attitude data text file from dialog
 fnami_f = Dialog_Pickfile(/Read, Filter = '*.txt',   $
        Title = 'Input File Name for Fit Attitude Data' )
 Print, 'Opening File ',fnami_s
 OpenR, unit_f, fnami_f, /Get_Lun
```

```
;
; ... Read in Spacecraft data
 ReadF, unit_s, hdr_s       ;  read (& skip) the header text
 nf_s = 0
 While (NOT EOF(unit_s)) Do Begin
      ReadF, unit_s, spacecraft_in
      spc[nf_s] = spacecraft_in
      nf_s = nf_s + 1
 EndWhile
 Free_Lun, unit_s
 IF nf_s LT 1 Then Begin
    Print, 'Error exit; no valid data read from ' + fnami_s
    Return
 EndIf
 spc = spc[0:nf_s-1]
 Print, nf_s, ' spacecraft data records were read from ' + fnami_s
;
; ... Read in Fit Attitude data
 ReadF, unit_f, hdr_f       ;  read (& skip) the header text
 nf_f = 0
 While (NOT EOF(unit_f)) Do Begin
      ReadF, unit_f, fit_att_in
      fit[nf_f] = fit_att_in
      nf_f = nf_f + 1
 EndWhile
 Free_Lun, unit_f
 IF nf_f LT 1 Then Begin
    Print, 'Error exit; no valid data read from ' + fnami_f
    Return
 EndIf
 fit = fit[0:nf_f-1]
 Print, nf_f, ' attitude data records were read from ' + fnami_f
;
 ax_ntrp = Spline(spc.trel, spc.ax, fit.trel)
 ay_ntrp = Spline(spc.trel, spc.ay, fit.trel)
 az_ntrp = Spline(spc.trel, spc.az, fit.trel)
;
; Renormalize these interpolated estimates so that each is a true unit vector
 For k=0,nf_f-1 Do Begin
    rss = Sqrt(ax_ntrp[k]^2 + ay_ntrp[k]^2 + az_ntrp[k]^2)
    ax_ntrp[k] = ax_ntrp[k] / rss
    ay_ntrp[k] = ay_ntrp[k] / rss
    az_ntrp[k] = az_ntrp[k] / rss
 EndFor
;
; SVD use taken from IDL's HELP section on Linear Systems, set A & B values here
 a = [ Reform(ax_ntrp, 1,nf_f), Reform(ay_ntrp, 1,nf_f),  $
              Reform(az_ntrp, 1,nf_f) ]
 b = fit.cos
; Compute the singular value decomposition of A:
 SVDC, a, w, u, v
 n = N_elements(w)
 wp = DblArr(n, n)
 For k = 0, n-1 Do $
   If ABS(w(k)) GE 1.0e-5 Then wp(k, k) = 1.0/w(k)
    x = v ## wp ## Transpose(u) ## b
; Print the solution:
 Print, x, Format='(" The boresight vector x-, y-, and z-components are : ",' $
                  + ' 3(f15.10,:,", ") )'
;
; Open output file (overwrite if it already exists)
 Print, '     Choose Output Filename (will be overwritten ' +  $
        'if it already exists)'
 fnamw = Dialog_Pickfile( Filter = '*.txt',                    $
           Title = 'Choose Interpolated Data output file')
```

```
 OpenW, unitw, fnamw, /Get_Lun
; print the solution here
 PrintF, unitw, tb, x[0],tb,x[1],tb,x[2], Format='(" The boresight vector '   $
    + 'x-, y-, and z-components are : ", 3(a1,f15.10) )'
 PrintF, unitw, hdr_f,tb,'ax_intrp',tb,'ay_intrp',tb,'az_intrp'
 fmta = '(f12.3,a1,  f9.4, 4(a1,f12.7) )'
 For j = 0, nf_f-1 Do PrintF, Format = fmta, unitw, fit[j].trel, $
    tb, fit[j].att, tb, fit[j].cos, tb, ax_ntrp[j], tb,          $
    ay_ntrp[j], tb, az_ntrp[j]
 Free_lun, unitw

 Return
;
END      ; end of procedure Interp_AbCal_Data
```

Abbreviations & Acronyms

ADFC	Altimetry Data Fusion Center
CAL	Calibration Mode or Calibration Mode data
Cal/Val	Calibration and Validation
CPU	Central Processing Unit
CSM	Command Storage Memory
DC####	Support run at Detachment Charlie for rev ####
DDL	Direct Downlink Mode (mode 4)
Det A	Detachment Alfa (Prospect Harbor, ME)
Det C	Detachment Charlie (Guam)
DSU	Digital Storage Unit
DTU	Digital Telemetry Unit
EDAC	Error Detection and Correction Circuits
EEPROM	Electrically Erasable Programmable Read Only Memory
ENG	Engineering Data
ERO	Exact Repeat Orbit
FTP	File Transfer Protocol
GEOSAT	Geodetic Satellite
GFO	GEOSAT Follow-On
GMT	Greenwich Mean Time
GPS	Global Positioning System
GPSR	GPS Receiver
GSFC	Goddard Space Flight Center
HPA	High Power Amplifier
HQ	Headquarters
HQ ISCS	Integrated Satellite Control System (NAVSOC's ground system at HQ for controlling satellites)
HQ RDCC	Remote Doppler Collection Computer at HQ
HW	Hardware
IAP	Integrated Avionics Processor

IDL	Interactive Data Language
LP	Laguna Peak, California
MOE	Medium-accuracy Orbit Ephemerides
NAVO	NAVOCEANO
NAVOCEANO	Naval Oceanographic Office
NAVSOC	Naval Satellite Operations Center
NCEP	National Centers for Environmental Prediction
NCEU	NAVSOC Command Encoder Unit
NGDR	NOAA Geophysical Data Record
NHRSCC	an ascii file of the 1200 clock pairs used to compute an SCC
NSI	NASA Science Internet
OODD	Operational Orbit Determination Data
POC	Payload Operations Center
POE	Precision Orbit Ephemerides
PSK	Phase Shift Key
QSCAT	NASA QuikSCAT satellite
RA	Radar Altimeter
RAM	Read Access Memory
RASE	Radar Altimeter System Evaluator
RMS	Root Mean Square
SCC	Satellite Clock Coefficient
SCI	Science Data
SDR	Science Data Record
SDT	Science Definition Team
SMA	Semi-Major Axis of the orbit
SW	Software
TMON	Telemetry Monitor Support
TRK	Track Mode
TTCS	Time Tag Correction System
UTC	Universal Time Code
VTCW	Vehicle Time Code Word

WF	Waveform Data
WFF	Wallops Flight Facility
WVR	Water Vapor Radiometer
XM	Transmitter
XMMODHI/LO	Transmitter has a modulation setting of either High or Low

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13. ABSTRACT *(Maximum 200 words)*

The U.S. Navy's Geosat Follow-On (GFO) Mission, launched on February 20, 1998, is one of a series of altimetric satellites which include Seasat, Geosat, ERS-1, and TOPEX/POSEIDON (T/P). The purpose of this report is to document the GFO altimeter performance determined from the analyses and results performed by NASA's GSFC and Wallops altimeter, calibration team. It is the third of an anticipated series of NASA's GSFC and Wallops GFO performance documents, each of which will update assessment results. This report covers the performance from instrument acceptance by the Navy on November 29, 2000, to the end of Cycle 42 on November 30, 2002. Data derived from GFO will lead to improvements in the knowledge of ocean circulation, ice sheet topography, and climate change. In order to capture the maximum amount of information from the GFO data, accurate altimeter calibrations are required for the civilian data set which NOAA will produce. Wallops Flight Facility has provided similar products for the Geosat and T/P missions and is doing the same for GFO.

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