GFO RADAR ALTIMETER PERFORMANCE

June 12, 2001

NOAA Laboratory for Satellite Altimetry
Silver Spring, Maryland

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NASA GSFC/Wallops Flight Facility, Code 972
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NAVY - Wallops Data Flow

Daily

RA Data (without waveforms)
RA Cal Data (with waveforms)
ENG Data (engineering)
WVR Data (water vapor)
Sensor Data Records (SDR)

As Soon As Available

Navy Geophysical Data Records (NGDR)
OODD (orbit)

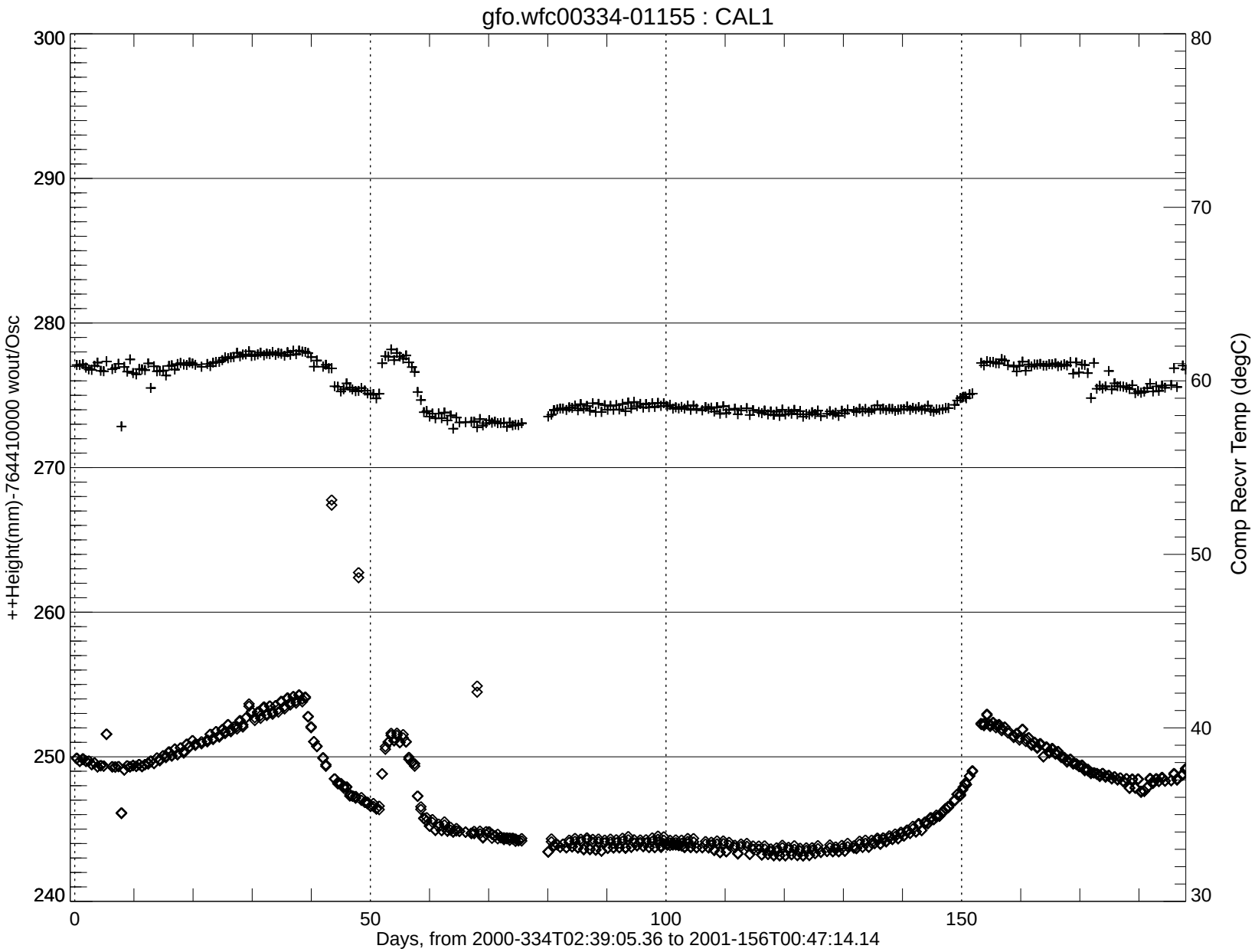
Wallops - Cal/Val Team Data Flow

SDR
RA Cal Data
OODD

Wallops-Recommended Editing Criteria
Quality Word #1

- **Record is zero filled (bit 2)**
- **RA not in fine track (bit 3)**
- **Receiver Temperature error (bit 5)**
- **No smoothed VATT(bit 7)**
- **SWH bounds error (bit 10)**
- **Off Nadir error (bit 18)**
- **SWH STD error (bit 19)**
- **RA data frame missing (bits 22-31) (greater than 5 missing)**

Note: Also be sensitive to the invalid value fill data. Bit 5 test has been used on data since acceptance.


gfo.wfc00334-01155 : CAL1
++Height(mm)-764410000 wout/Osc
Comp Recvr Temp (degC)
Days, from 2000-334T02:39:05.36 to 2001-156T00:47:14.14
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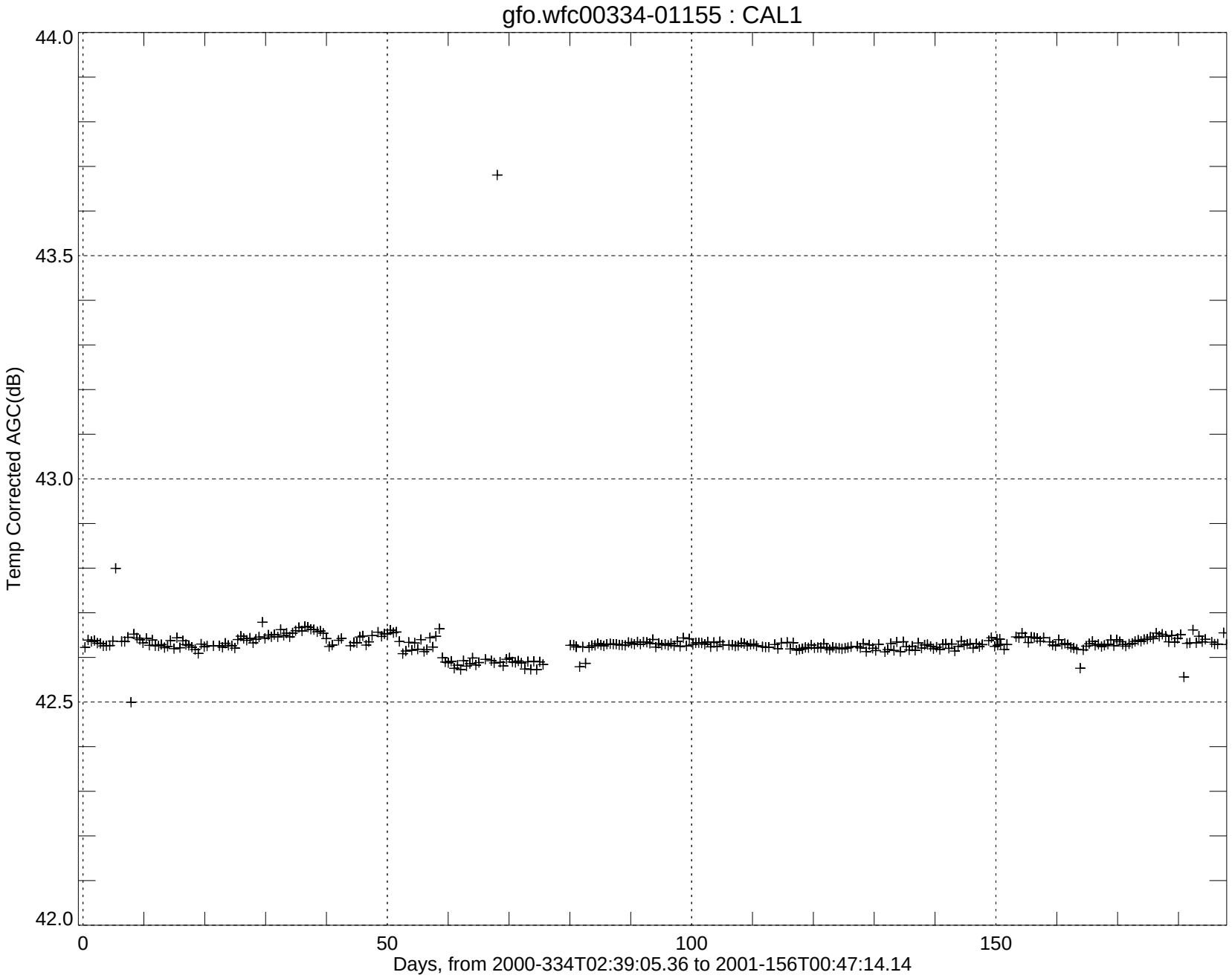
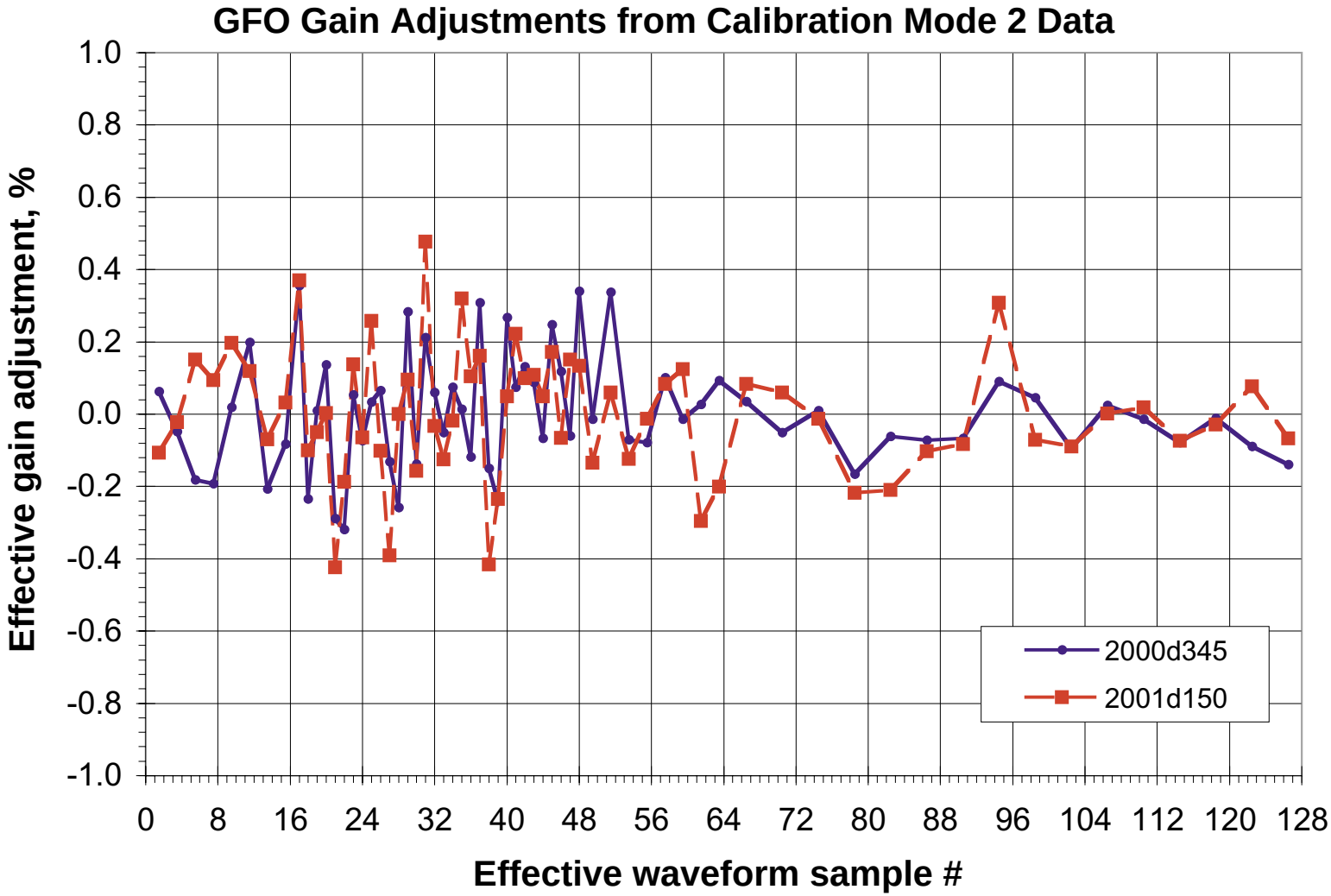
290
280
270
260
250
240
80
70
60
50
40
30
0
50
100
150


gfo.wfc00334-01155 : CAL1
Temp Corrected AGC(dB)
44.0
43.5
43.0
42.5
42.0
0
50
100
150
Days, from 2000-334T02:39:05.36 to 2001-156T00:47:14.14

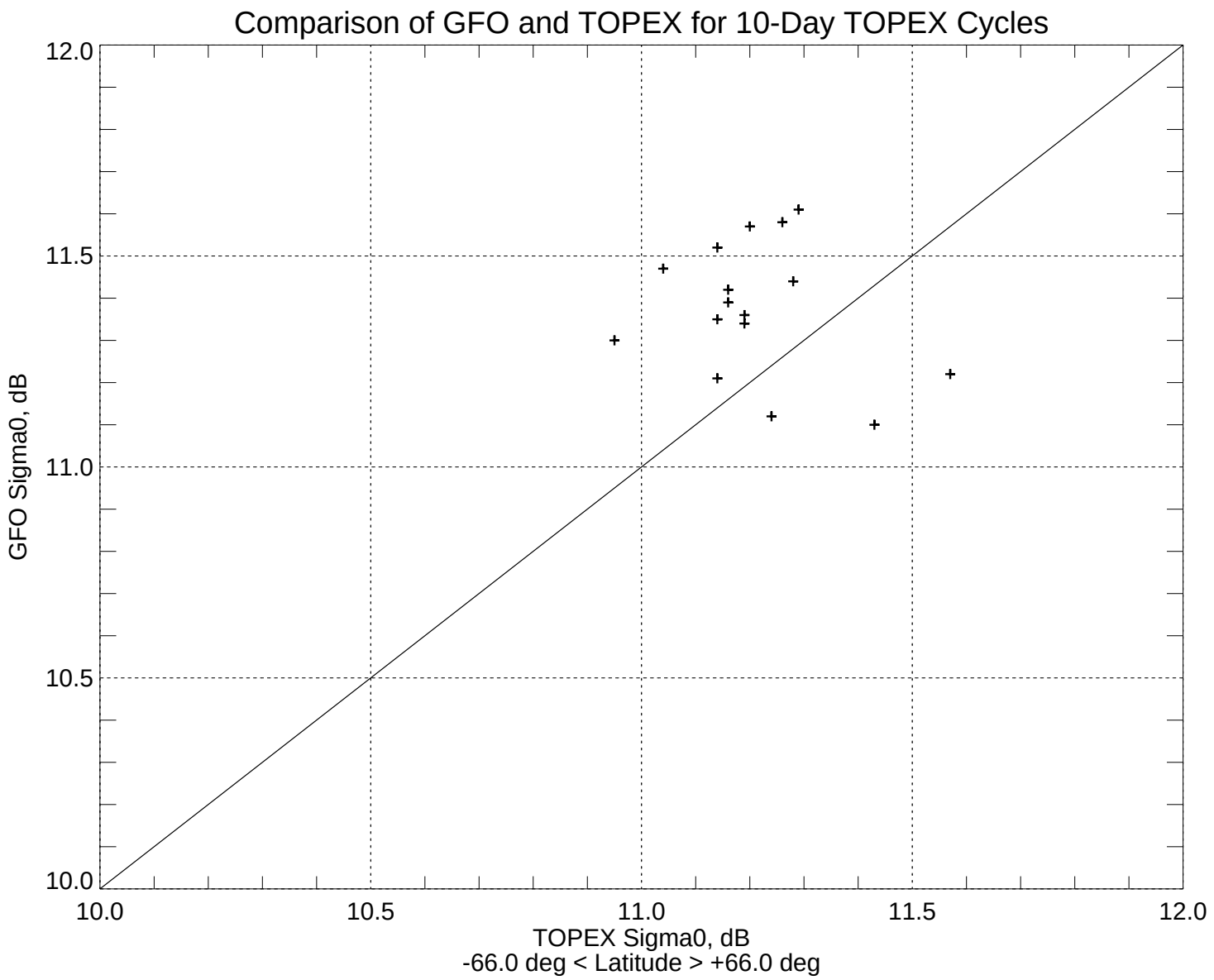

GFO Gain Adjustments from Calibration Mode 2 Data
Effective gain adjustment, %
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0
8
16
24
32
40
48
56
64
72
80
88
96
104
112
120
128
Effective waveform sample #
2000d345
2001d150

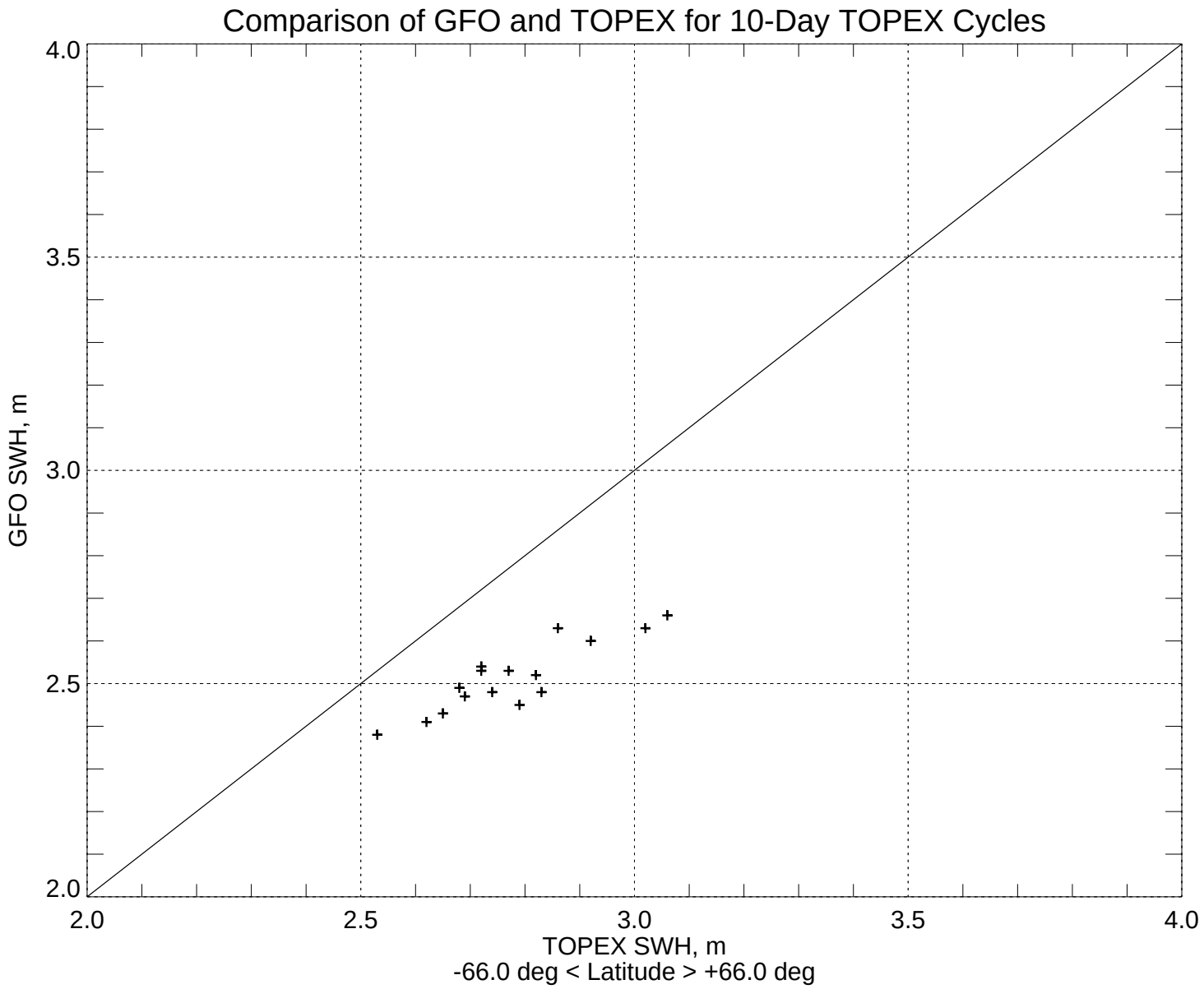
Comparison of GFO and TOPEX (Ku) Sigma0 Means for 10-Day TOPEX Cycles

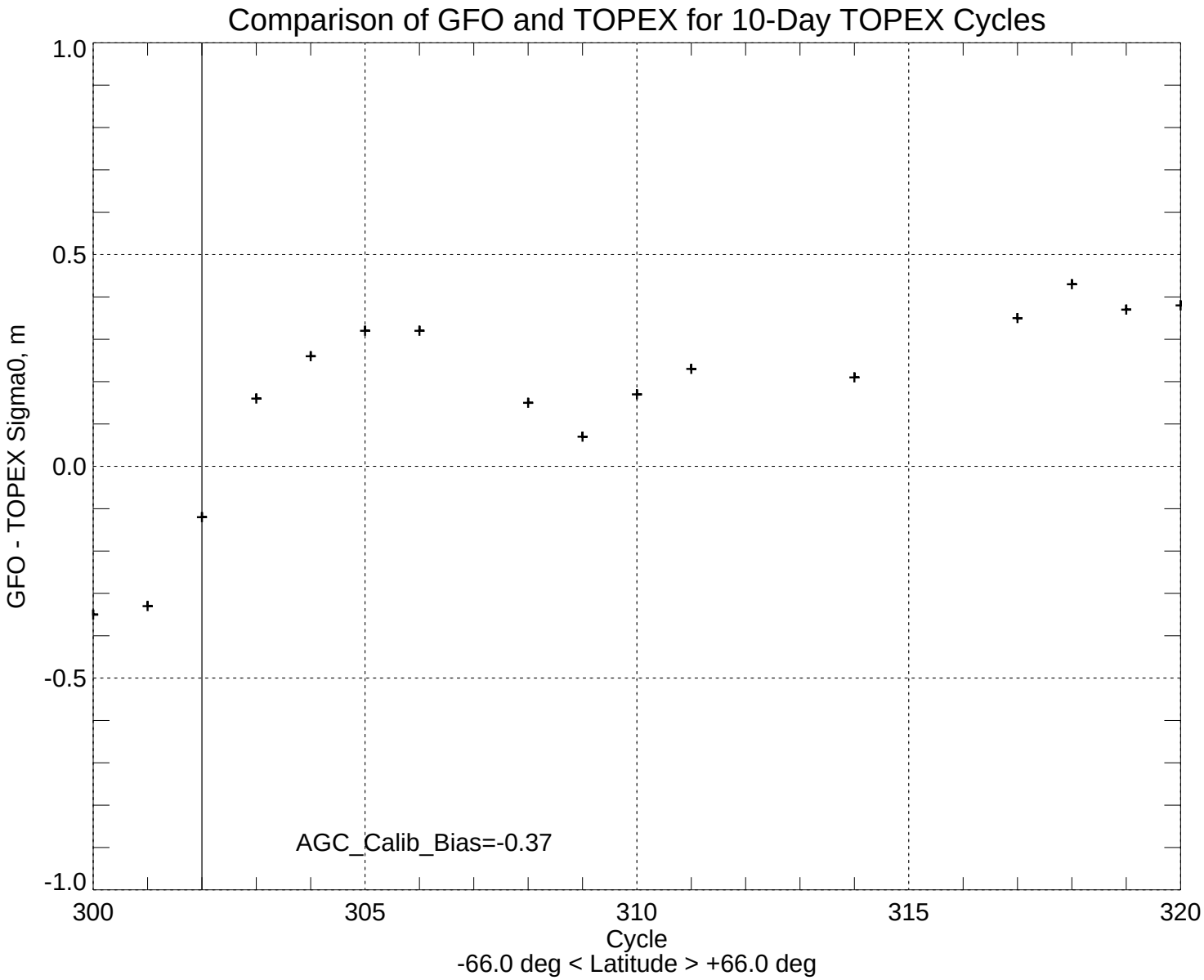
TOPEX Cycle Number	Start Day-of-Year	End Day-of-Year	GFO Number of Data Points Processed	TOPEX Number of Data Points Processed	GFO Mean Sigma0 (dB)	TOPEX Ku Mean Sigma0 (dB)	Delta Sigma0 (dB) GFO-TOPEX
300	2000-309t22:23	2000-319t20:07	361900	409012	11.22	11.57	-0.35
301	2000-319t20:22	2000-329t04:40	373232	371940	11.10	11.43	-0.33
302	2000-330t09:18	2000-339t16:03	389634	321292	11.12	11.24	-0.12
303	2000-339t16:18	2000-349t14.03	382594	348866	11.44	11.28	0.16
304	2000-349t14:11	2000-359t12:08	421788	364801	11.42	11.16	0.26
305	2000-359t12:09	2001-003t10:07	370730	366629	11.58	11.26	0.32
306	2001-003t10:08	2001-013t08:06	417865	370715	11.61	11.29	0.32
308	2001-023t06:05	2001-033t04:02	404536	379845	11.34	11.19	0.15
309	2001-033t04:03	2001-043t02:01	453364	384927	11.21	11.14	0.07
310	2001-043t02:02	2001-053t00:00	251597	382321	11.36	11.19	0.17
311	2001-053t00:01	2001-062t22:00	459435	381019	11.39	11.16	0.23
314	2001-082t17:56	2001-092t15:53	459715	375545	11.35	11.13	0.22
317	2001-112t11:52	2001-122t09:48	438150	369260	11.30	10.95	0.35
318	2001-122t09:51	2001-132t07:47	476917	367090	11.47	11.04	0.43
319	2001-132t07:50	2001-142t05:40	424545	352383	11.57	11.20	0.37
320	2001-142t05:52	2001-152t03:39	398206	346926	11.52	11.14	0.38

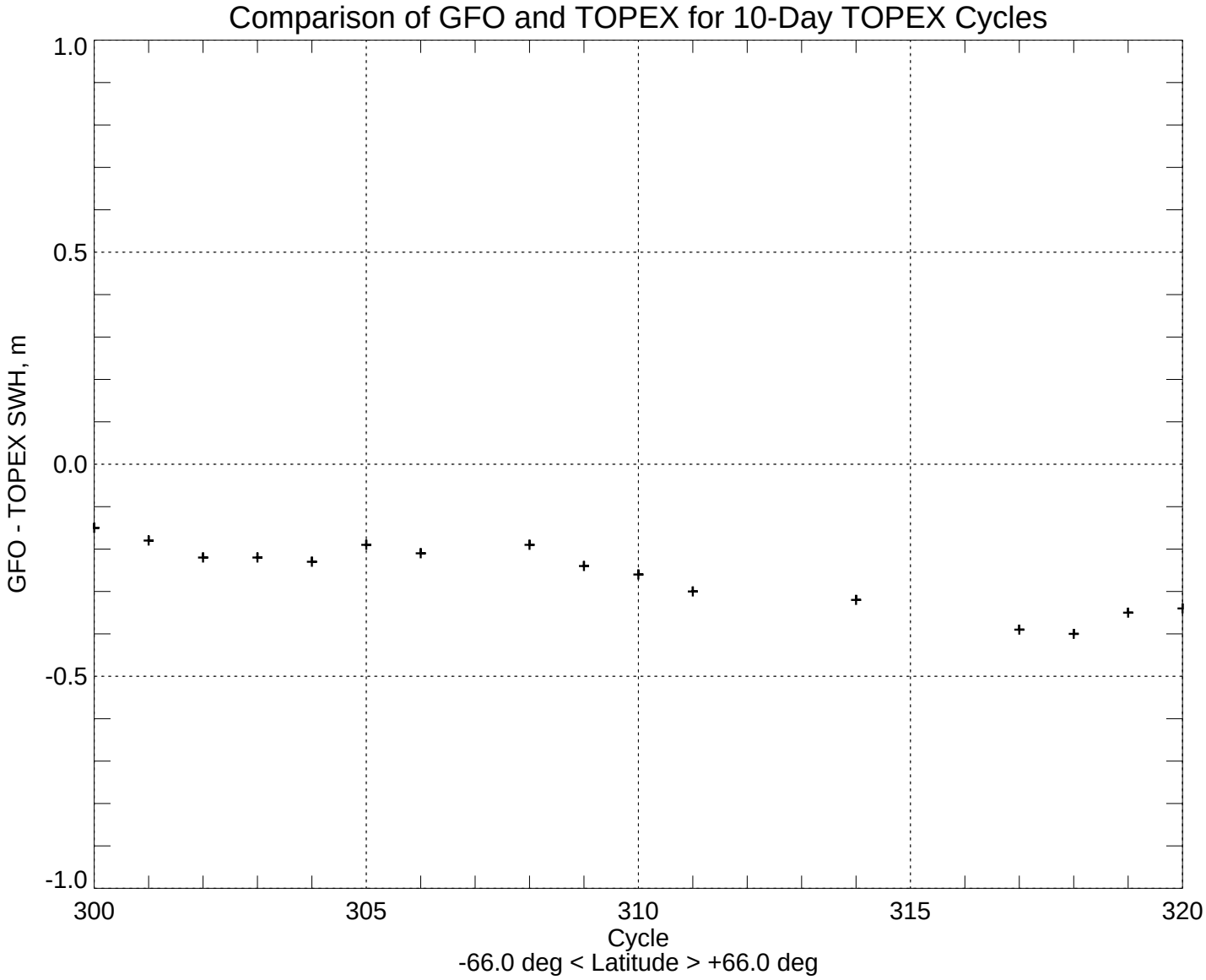
Comparison of GFO and TOPEX (Ku) SWH Means for 10-Day TOPEX Cycles

TOPEX Cycle Number	Start Day-of-Year	End Day-of-Year	GFO Number of Data Points Processed	TOPEX Number of Data Points Processed	GFO Mean SWH (m)	TOPEX Ku Mean SWH (m)	Delta SWH(m) GFO-TOPEX
300	2000-309t22:23	2000-319t20:07	361900	409012	2.38	2.53	-0.15
301	2000-319t20:22	2000-329t04:40	373232	371940	2.54	2.72	-0.18
302	2000-330t09:18	2000-339t16:03	389634	321292	2.47	2.69	-0.22
303	2000-339t16:18	2000-349t14.03	382594	348866	2.43	2.65	-0.22
304	2000-349t14:11	2000-359t12:08	421788	364801	2.63	2.86	-0.23
305	2000-359t12:09	2001-003t10:07	370730	366629	2.53	2.72	-0.19
306	2001-003t10:08	2001-013t08:06	417865	370715	2.41	2.62	-0.21
308	2001-023t06:05	2001-033t04:02	404536	379845	2.49	2.68	-0.19
309	2001-033t04:03	2001-043t02:01	453364	384927	2.53	2.77	-0.24
310	2001-043t02:02	2001-053t00:00	251597	382321	2.48	2.74	-0.26
311	2001-053t00:01	2001-062t22:00	459435	381019	2.52	2.82	-0.30
314	2001-082t17:56	2001-092t15:53	459715	375545	2.60	2.92	-0.32
317	2001-112t11:52	2001-122t09:48	438150	369260	2.63	3.02	-0.39
318	2001-122t09:51	2001-132t07:47	476917	367090	2.66	3.06	-0.40
319	2001-132t07:50	2001-142t05:40	424545	352383	2.48	2.83	-0.35
320	2001-142t05:52	2001-152t03:39	398206	346926	2.45	2.79	-0.34


Comparison of GFO and TOPEX for 10-Day TOPEX Cycles
12.0
11.5
11.0
10.5
10.0
GFO Sigma0, dB
10.0
10.5
11.0
11.5
12.0
TOPEX Sigma0, dB
-66.0 deg < Latitude > +66.0 deg


Comparison of GFO and TOPEX for 10-Day TOPEX Cycles
4.0
3.5
3.0
2.5
2.0
GFO SWH, m
2.0
2.5
3.0
3.5
4.0
TOPEX SWH, m
-66.0 deg < Latitude > +66.0 deg

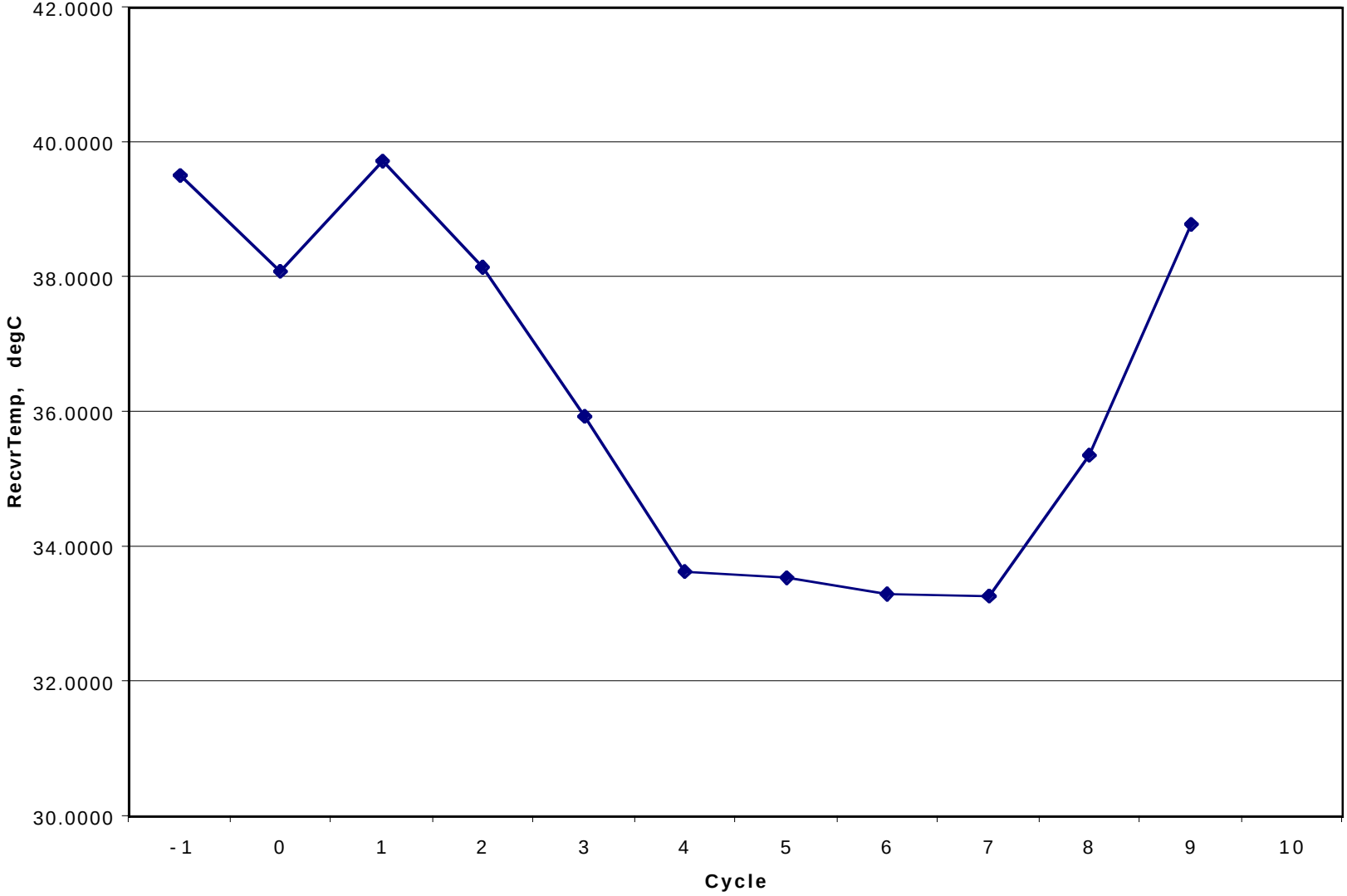

Comparison of GFO and TOPEX for 10-Day TOPEX Cycles
GFO - TOPEX Sigma0, m
1.0
0.5
0.0
-0.5
-1.0
300
305
310
315
320
Cycle
AGC_Calib_Bias=-0.37
-66.0 deg < Latitude > +66.0 deg


Comparison of GFO and TOPEX for 10-Day TOPEX Cycles
1.0
0.5
0.0
-0.5
-1.0
GFO - TOPEX SWH, m
300
305
310
315
320
Cycle
-66.0 deg < Latitude > +66.0 deg

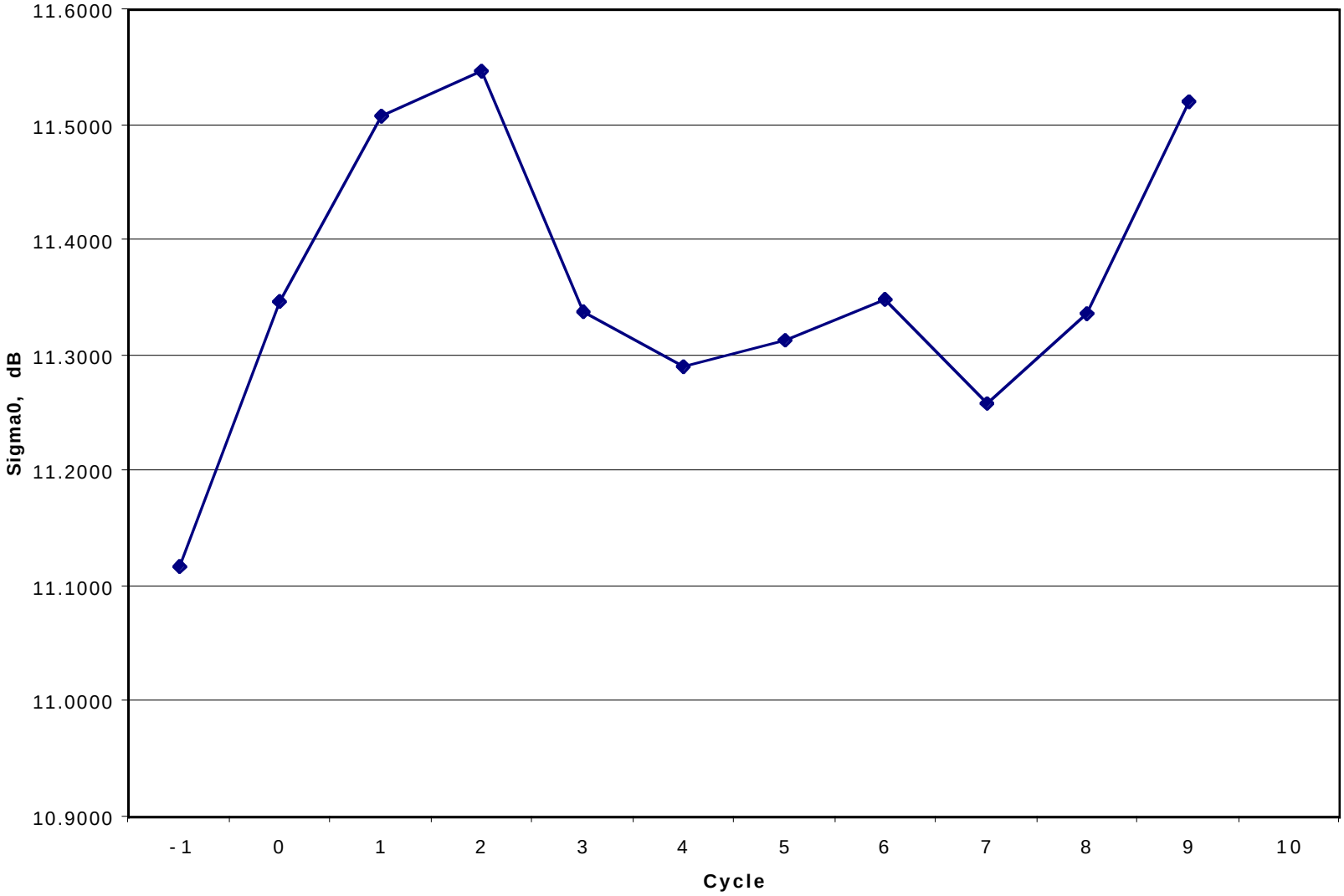
GFO Cycle Summaries

Cycle	Days in Cycle	SSHUSTD, m	SWH, m	Sigma0, dB	AGC, dB	Attitude, deg	RecvrTemp, C	WindSpeed, .1m/s	# Points Used
-1	00318 - 00334	0.0433	2.5028	11.1167	42.9811	0.2487	39.5187	89.5435	709547
0	00335 - 00351	0.0426	2.4634	11.3467	43.2169	0.2392	38.1004	82.2133	661930
1	00352 - 01002	0.0435	2.5893	11.5076	43.3676	0.2502	39.7169	76.9435	670179
2	01003 - 01019	0.0421	2.4539	11.5464	43.4072	0.2422	38.1625	76.1032	705661
3	01020 - 01036	0.0424	2.5145	11.3383	43.2053	0.2105	35.9461	82.4006	705066
4	01037 - 01053	0.0428	2.5048	11.2909	43.1539	0.234	33.6365	83.9581	575112
5	01054 - 01070	0.044	2.595	11.3143	43.1754	0.2362	33.5342	83.6164	792452
6	01071 - 01087	0.0443	2.6296	11.3496	43.2111	0.2335	33.3062	82.7288	778777
7	01088 - 01104	0.0448	2.6688	11.2597	43.1205	0.2255	33.281	85.4292	727955
8	01105 - 01121	0.0442	2.611	11.3374	43.1974	0.227	35.3536	82.6415	781960
9	01122 - 01138	0.0445	2.5979	11.5202	43.3821	0.2361	38.792	77.0297	682787

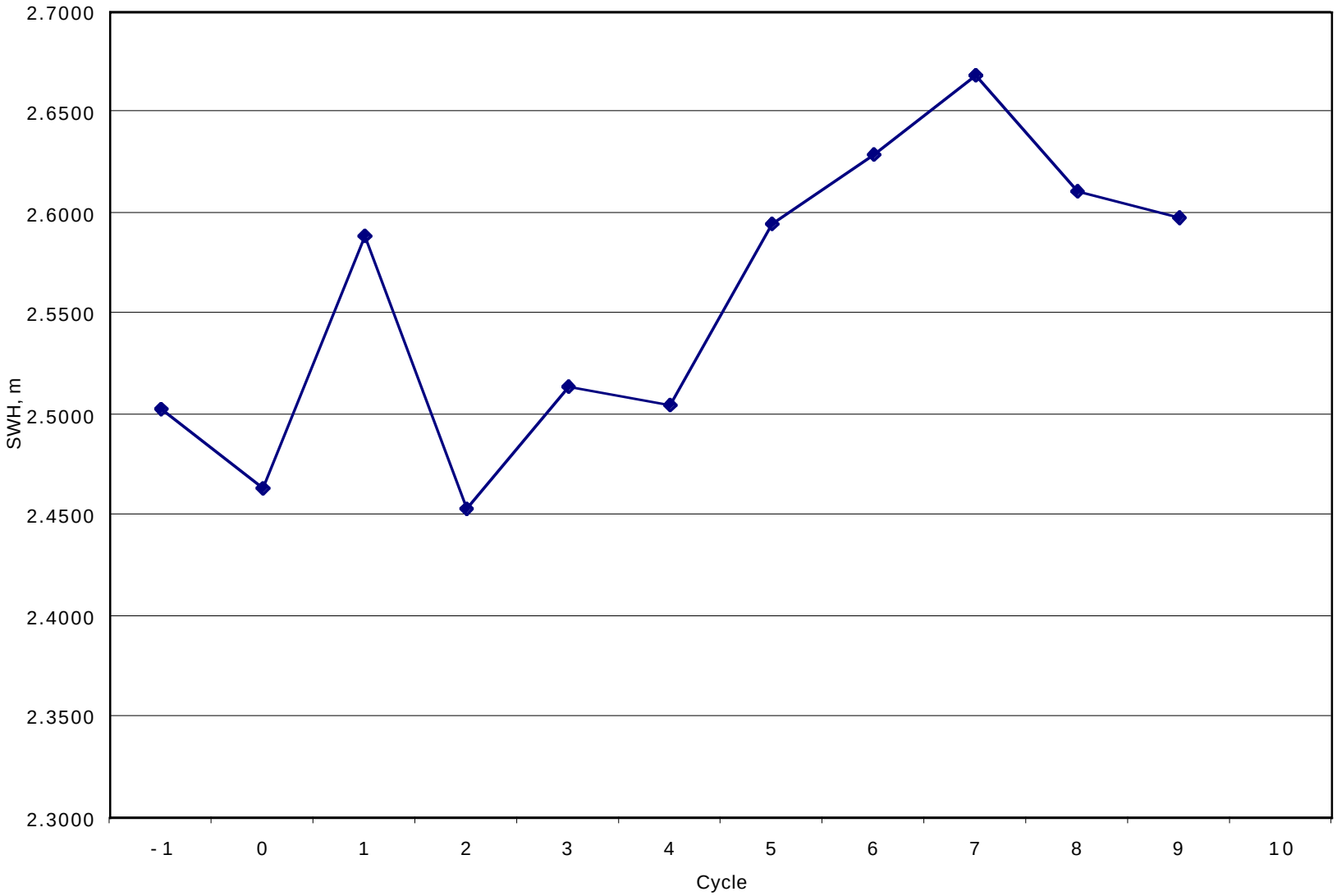
GFO Cycle Trend



GFO Cycle Trend



GFO Cycle Trend



Assessment of the Cycle- by- Cycle GFO Altimeter Noise Level by High-Pass Filtering 1- Hz Data

Method:

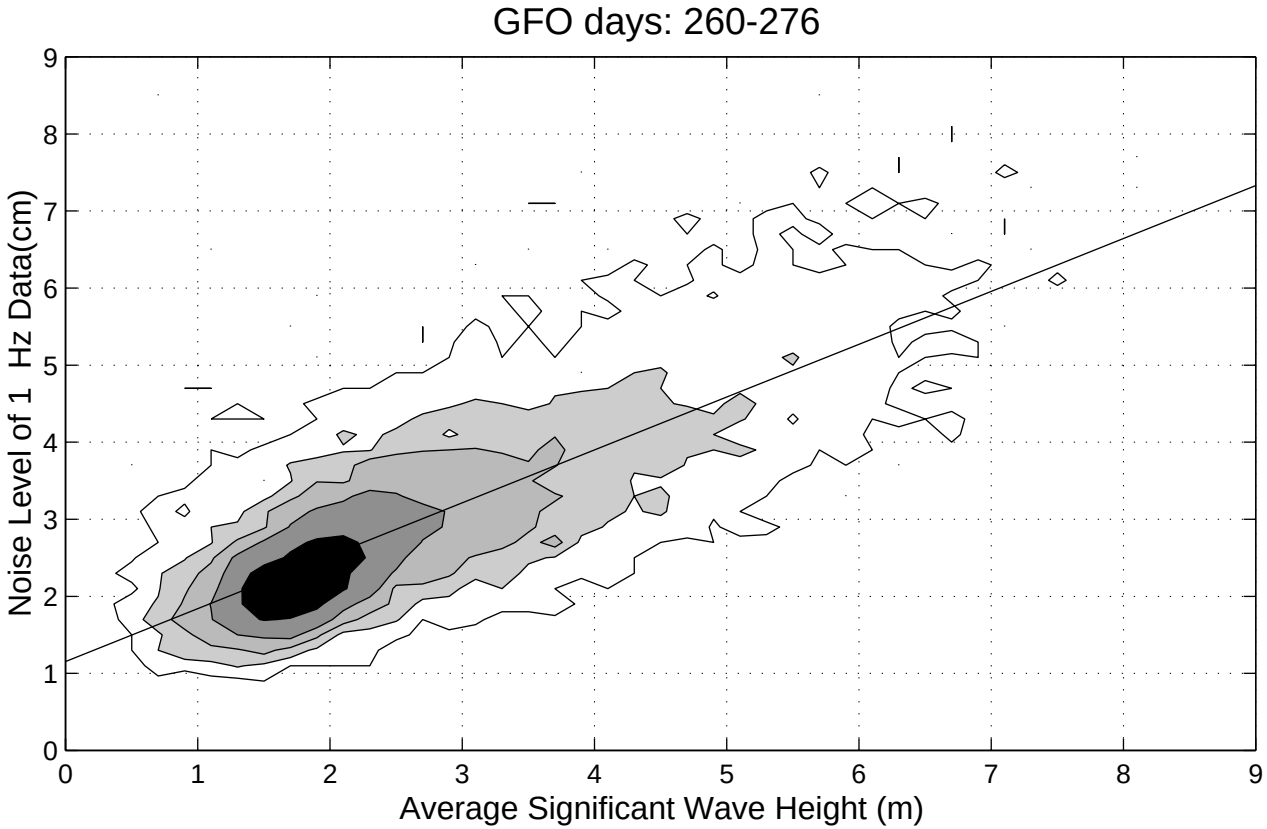
- Driscoll and Sailor [NASA Technical Report: NASA/TM-2001-209984/Vol. 2] have developed a new approach, to estimate GFO altimeter instrument noise, that works by high-pass filtering sea surface height 1- Hz data.
- We have tested a cycle-by-cycle noise level estimation routine.
- The high- pass filter is a 5th-order Butterworth filter (to remove the geoid and all long- wavelength environmental signals) with a cutoff frequency of 0.30 Hz.

Data and Routine:

- GFO sea surface height data are from NGDR files.
- The measurements used are 1- second averages.
- These altimeter data are confined in space between 60 S and 60 N.
- The use of both GFO Quality Word I (bits: 0- 9, 10, 11, 12, 13, 21, 22, 24, 27, 28, and 29) and Quality Word II (bits: 18, 19, and 20) and criteria such as σ^0<16 dB and <SWH 10 m leads to gaps in the sea surface height time series. In order to not remove too many track segments, we filled the small gaps between 2 and 5 seconds by a linear interpolation.
- The high- pass filter has been applied on track segments of 290-310 samples (~5 minutes which correspond to 2000 km) and 50-70 samples (1 minute, ~400 km) respectively.
- Smaller segments in each case are not considered.

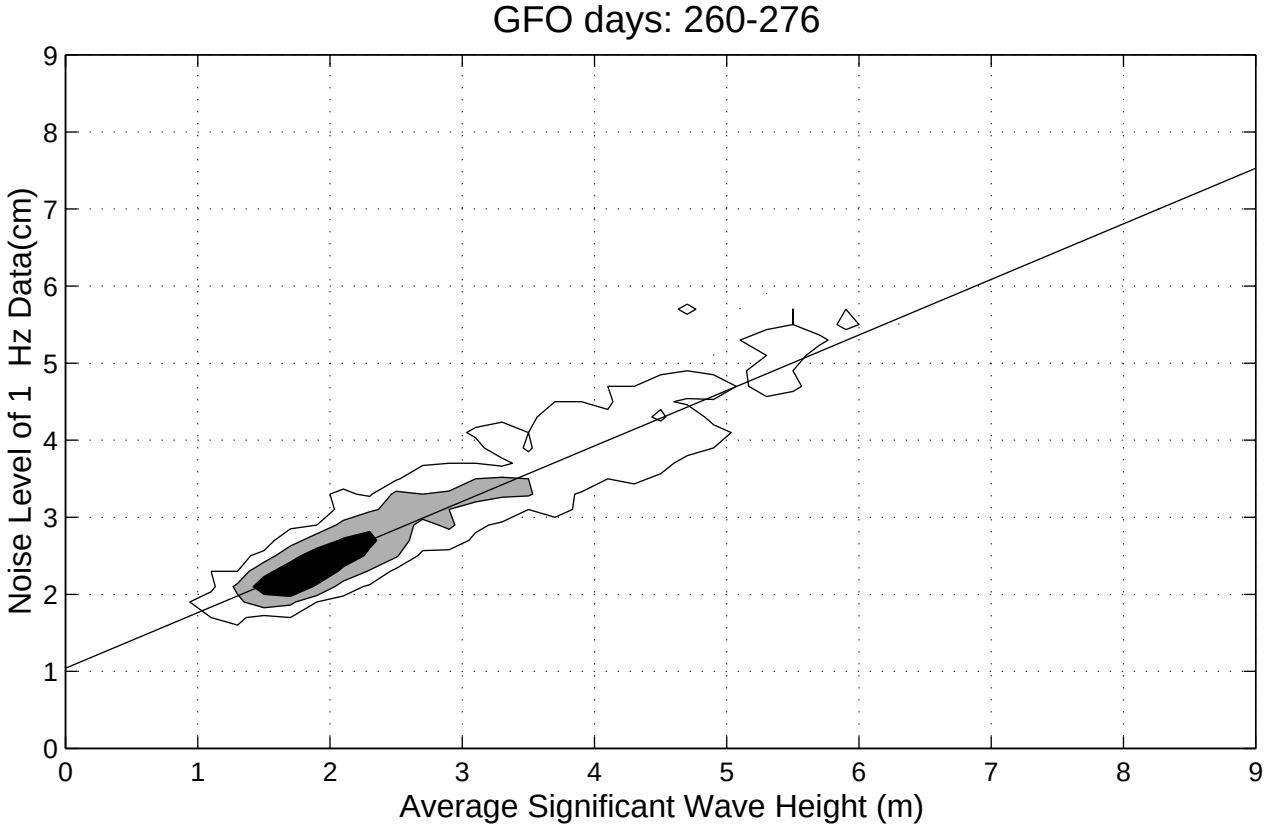
High- Pass Filtering Results for the 1- minute Segments over a 17- day Period

Year 2000



High- Pass Filtering Results for the 5- minute Segments over a 17- day Period

Year 2000



Statistical Indicators

Results for the 5-minute segments

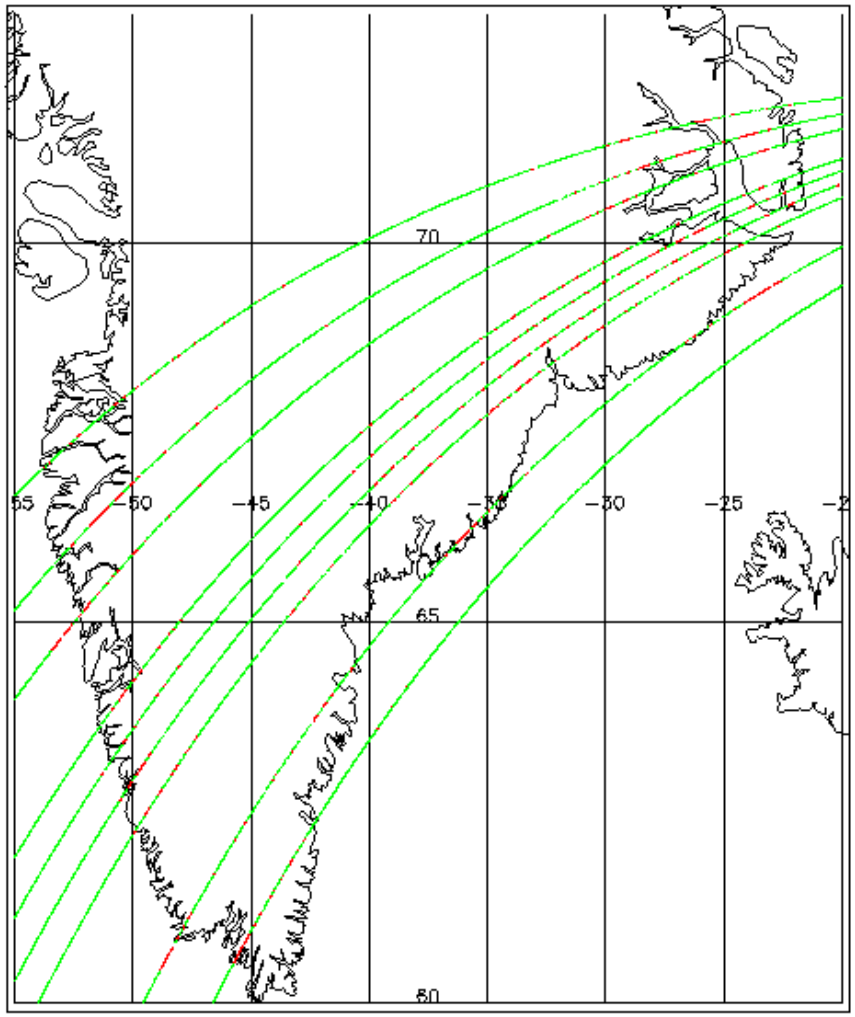
High-Pass Filter 5-min. Segments	Year or Cycle	No of Segments	Ku SWH		Noise Level (NL)		Noise Level vs. Ku SWH		
			Mean (m)	Std Dev (m)	Mean (cm)	Std Dev (cm)	Slope	Intercept	2m SWH Noise Level (cm)
days 260-276	2000	1102	2.78	1.18	3.07	0.93	0.75±0.01	0.99	2.49
days 277-293	2000	1132	2.71	1.08	3.01	0.86	0.74±0.01	0.98	2.47
days 352-002	01 (gfoM)	1465	2.70	1.06	3.08	0.87	0.76±0.02	1.01	2.54
days 003-019	02 (gfoM)	1548	2.59	1.04	3.00	0.87	0.77±0.02	1.01	2.55
days 020-036	03 (gfoM)	1524	2.61	0.99	3.00	0.79	0.73±0.02	1.09	2.56
days 037-053	04 (gfoM)	1221	2.59	0.97	2.97	0.80	0.75±0.02	1.03	2.53
days 054-070	05 (gfoo)	1636	2.69	1.08	3.10	0.85	0.72±0.01	1.15	2.60
days 071-087	06 (gfoo)	1619	2.72	1.04	3.11	0.83	0.72±0.02	1.16	2.60
days 088-104	07 (gfoo)	1361	2.74	1.05	3.11	0.83	0.72±0.02	1.14	2.57
days 105-121	08 (gfoo)	1676	2.64	1.06	3.03	0.79	0.69±0.01	1.21	2.58

Results for the 1-minute segments

High-Pass Filter 1-min. Segments	Year or Cycle	No of Segments	Ku SWH		Noise Level (NL)		Noise Level vs. Ku SWH		
			Mean (m)	Std Dev (m)	Mean (cm)	Std Dev (cm)	Slope	Intercept	2m SWH Noise Level (cm)
days 260-276	2000	9726	2.62	1.32	3.00	1.19	0.69±0.01	1.19	2.57
days 277-293	2000	9730	2.58	1.23	2.93	1.12	0.68±0.01	1.18	2.54
days 352-002	01 (gfoM)	10054	2.61	1.21	3.07	1.21	0.68±0.01	1.25	2.65
days 003-019	02 (gfoM)	10834	2.49	1.19	2.98	1.19	0.69±0.01	1.26	2.64
days 020-036	03 (gfoM)	10364	2.53	1.16	3.08	1.24	0.64±0.02	1.45	2.74
days 037-053	04 (gfoM)	8394	2.49	1.15	2.96	1.14	0.67±0.01	1.29	2.63
days 054-070	05 (gfoo)	11371	2.58	1.25	3.10	1.22	0.66±0.01	1.38	2.71
days 071-087	06 (gfoo)	11179	2.60	1.23	3.09	1.17	0.62±0.01	1.47	2.72
days 088-104	07 (gfoo)	9362	2.64	1.25	3.12	1.21	0.64±0.01	1.43	2.71
days 105-121	08 (gfoo)	11416	2.56	1.24	3.04	1.17	0.62±0.01	1.46	2.70

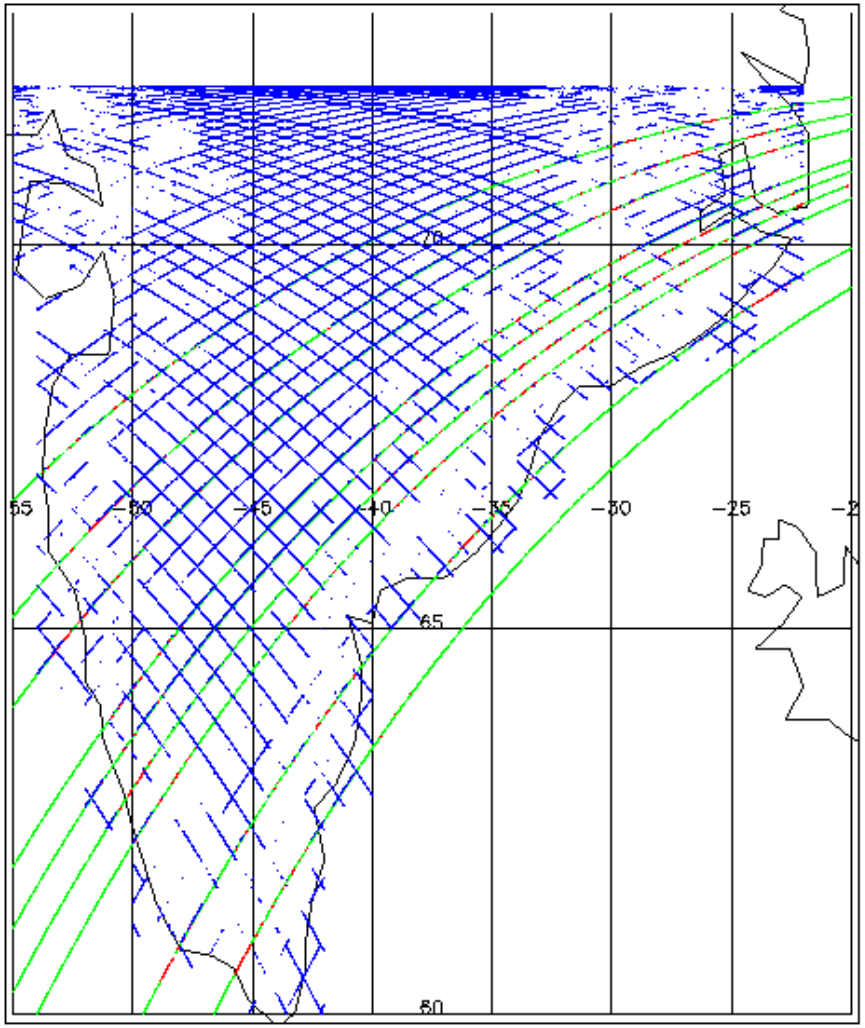
- **Comparison between 5- minute and 1- minute results:**
  - Larger variability of the noise level, for the 1-minute segments, with respect to the higher variability of the averaged significant wave height values.
  - Decrease of the mean of the Ku SWH distribution up to 5%.
  - Difference in the mean of the noise level distribution up to 2.7%.
  - Decrease of the slope of the linear fit between the noise level and the Ku significant wave height up to 14%.
  - Increase of the noise level value at 2 meters SWH up to 7%
- **Use of the high- pass filter:**
  - As shown by Driscoll and Sailor [2001], noise level estimates obtained by the high- pass filtering approach agree very well with the results from the repeat- track method.
  - The high- pass filter is easier to implement than the repeat-track method and allows a cycle-by-cycle check out on the altimeter noise.
  - The results obtained with the 1-minute segments do not differ much with the results for the 5-minute segments.
  - Since the results with the 5-minute segments show a smaller variability and need a smaller time of computation, we recommend the use of the high-pass filter approach with 5-minute segment-tracks.
  - This noise estimation can be applied to single-frequency altimeter data such as GFO or the French altimeter Poseidon as well as to dual-frequency altimeter data such as TOPEX.
  - This method allows comparison of the quality of different altimeters in a simple way.
- **Altimeter Performance**

Altimeter	5-minute segments				1-minute segment			
	NL (cm) vs. Ku SWH (m)	SWH (m)			NL (cm) vs. Ku SWH (m)	SWH (m)		
		2	4	6		2	4	6
GFO	0.735 SWH + 1.077	2.55	4.02	5.49	0.659 SWH + 1.336	2.65	3.97	5.29
TOPEX (w/o Iono)	0.411 SWH + 0.692	1.51	2.34	3.16	0.390 SWH + 0.766	1.55	2.33	3.11
Poseidon	-	-	-	-	0.496 SWH + 1.106	2.08	3.05	4.02



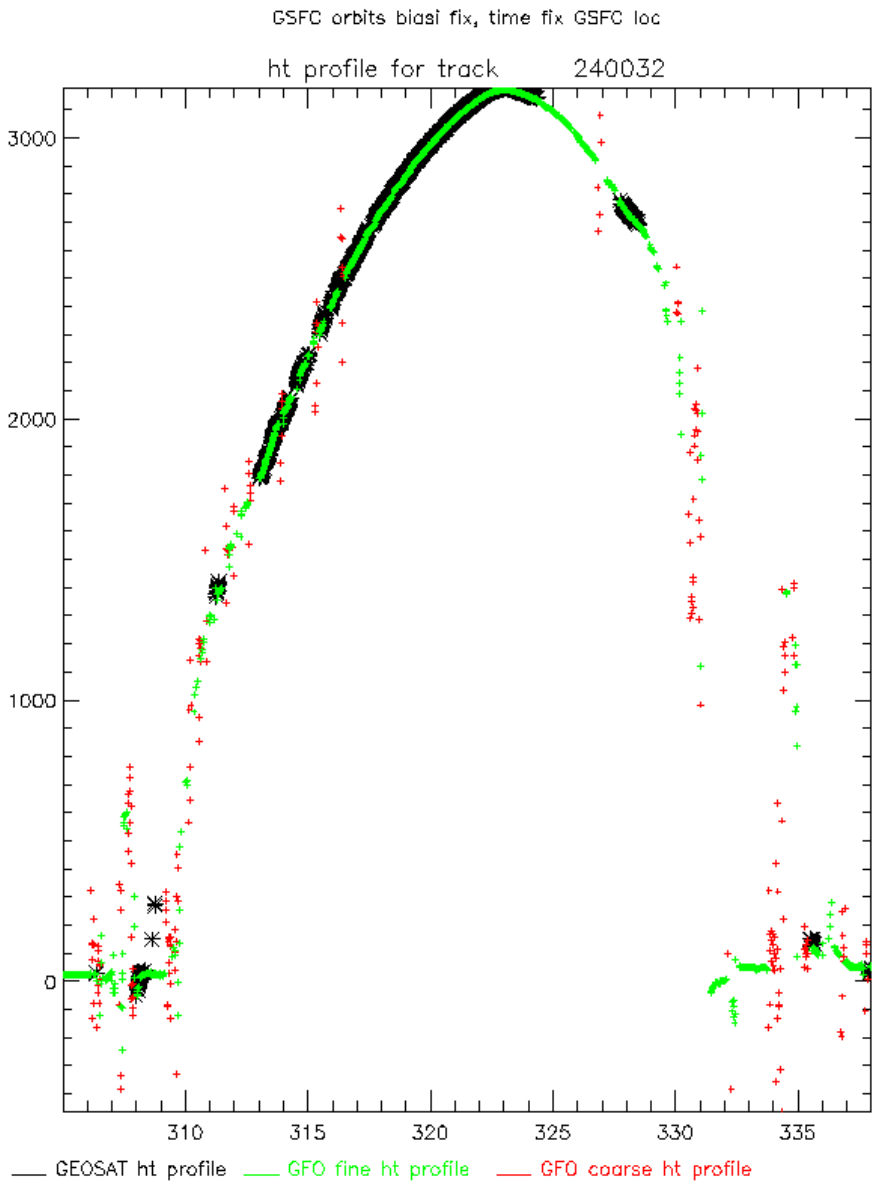
GFO Groundtracks over Greenland – green fine – red coarse
mjd beg 50948mjd end 50985

(Contributed by Anita Brenner/Raytheon ITSS)

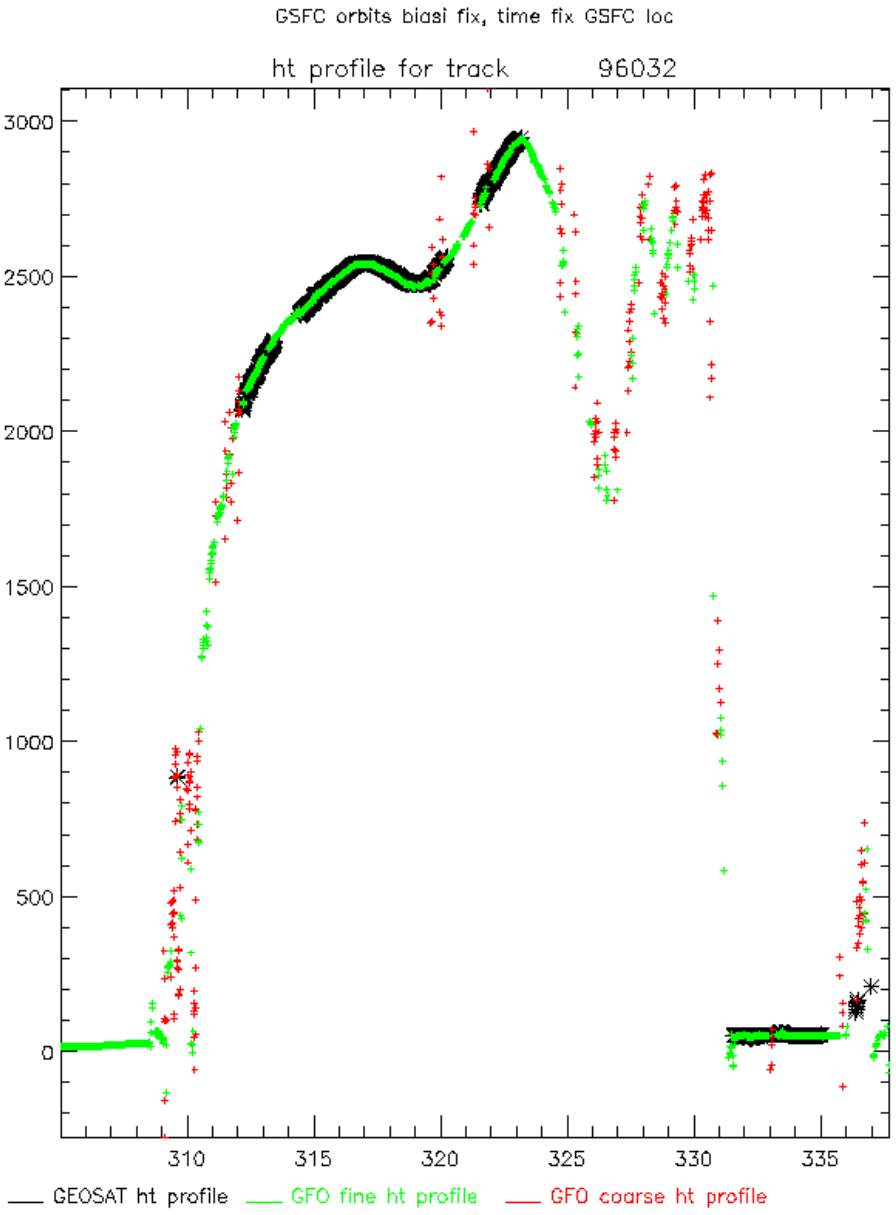


Geosat Groundtracks over Greenland 5/1/88–5/17/88
GFO Groundtracks over Greenland 5/15/98–6/21/98
red – GFO coarse mode; green – GFO find mode

(Contributed by Anita Brenner/Raytheon ITSS)



(Contributed by Anita Brenner/Raytheon ITSS)



(Contributed by Anita Brenner/Raytheon ITSS)

GFO Greenland Data

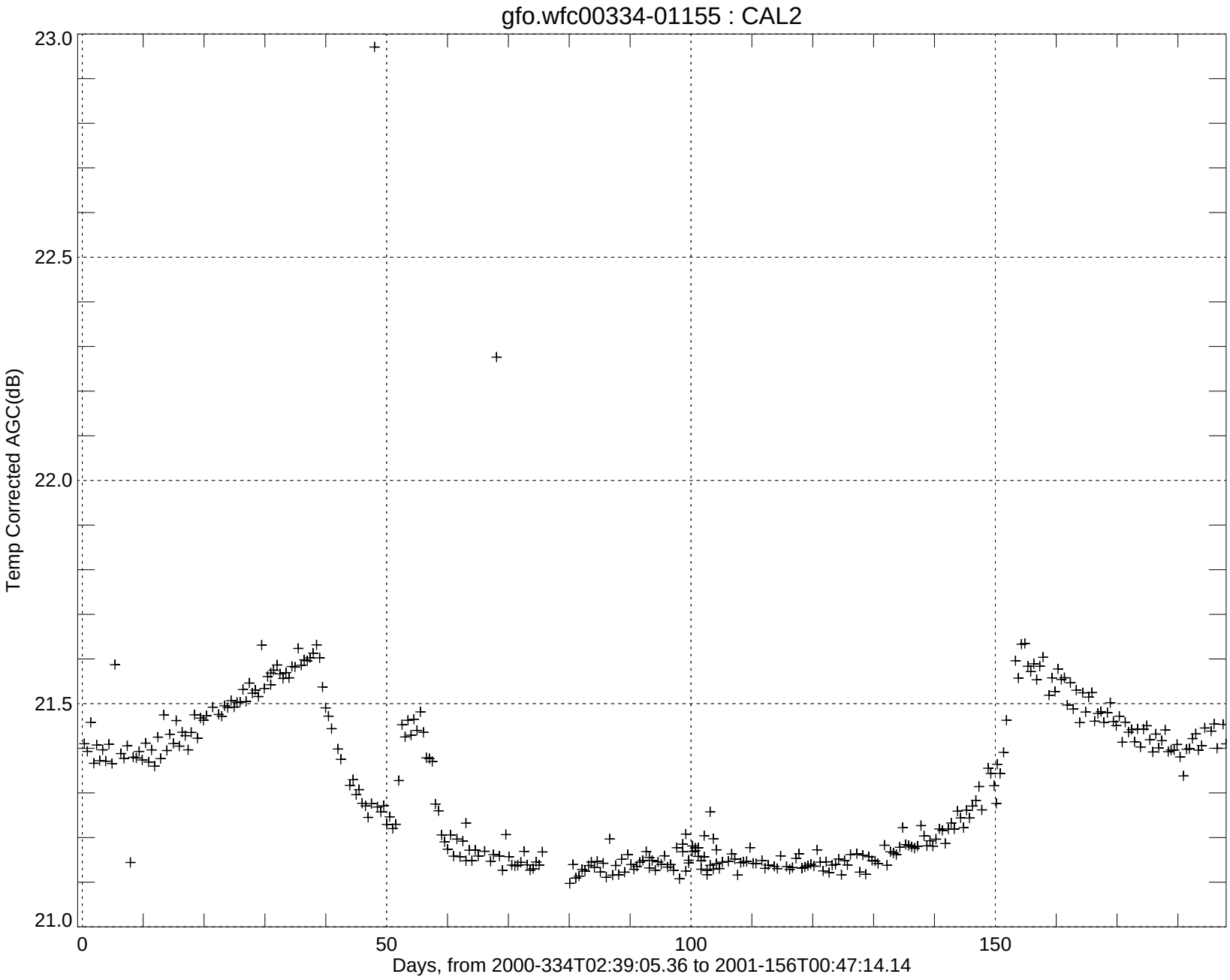
- **GFO tracks very well over Greenland**
- **Data is only one pass per day and no crossovers**
- **GFO mostly stays in track so very little data lost for acquisitions**
- **Operations to increase number of passes have been designed and may start in near future.**

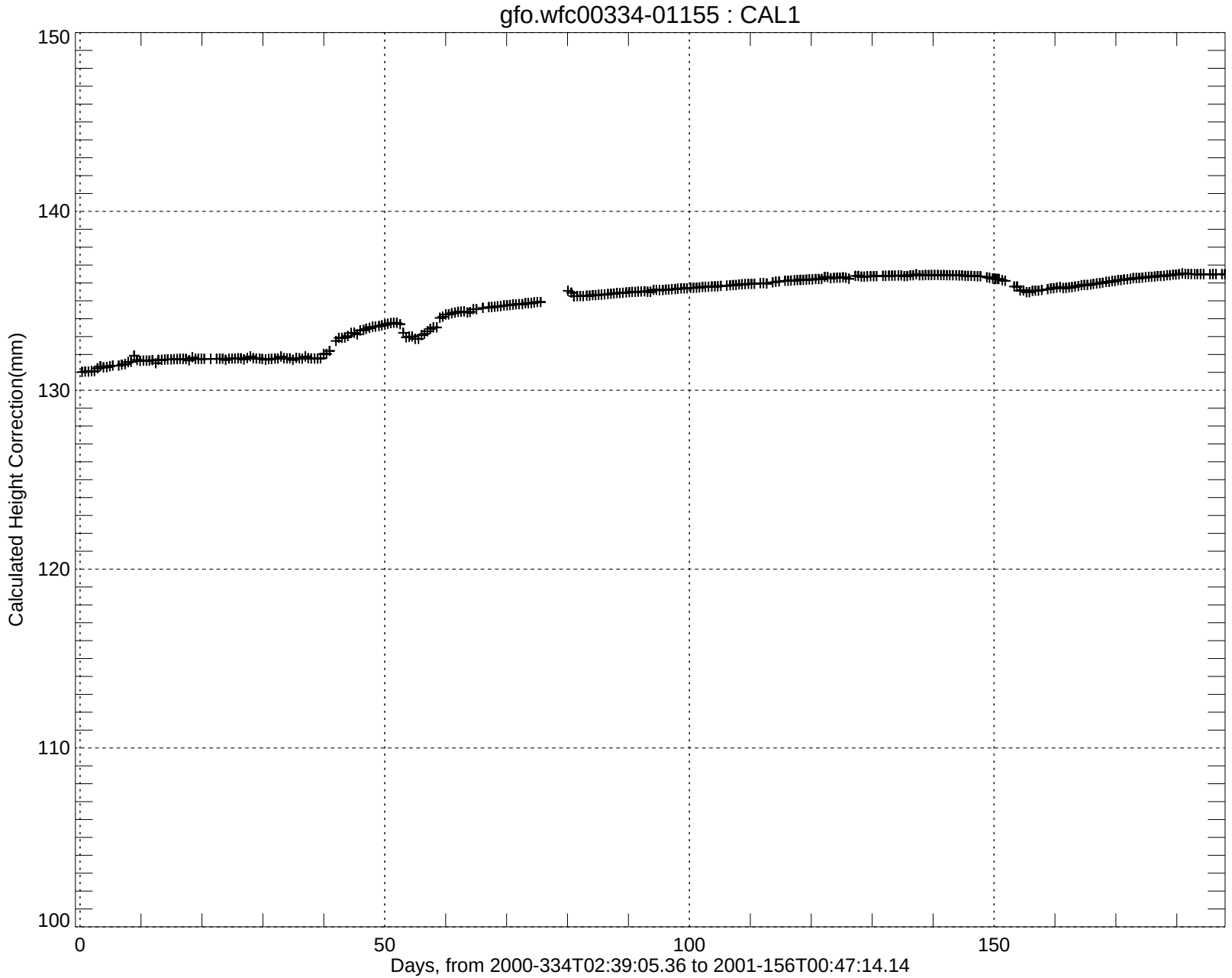
(Contributed by Anita Brenner/Raytheon ITSS)

WFF GFO Altimeter Assessment Conclusions

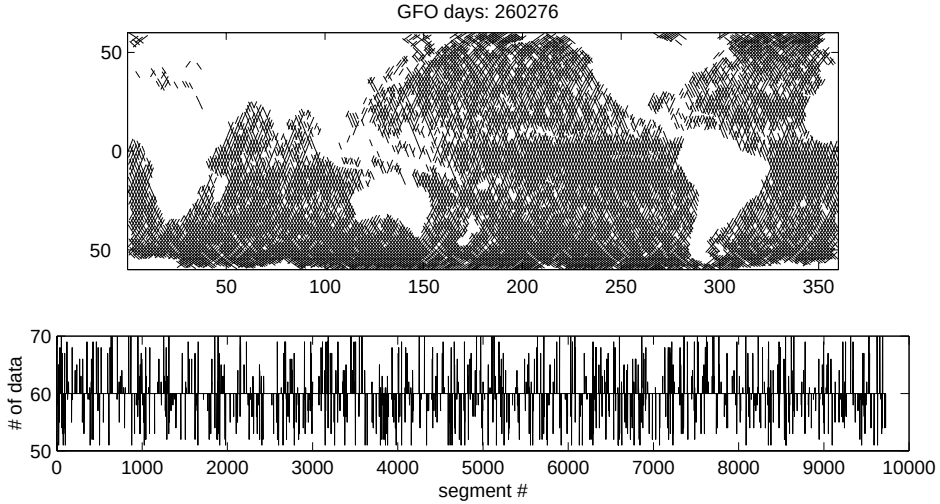
1. GFO altimeter performing well.
2. No significant height change.
3. No significant sigma0 change. Calibration correction applied makes GFO sigma0 slightly larger than TOPEX sigma0 but should improve windspeed estimate.
4. No change in height noise
5. Few full acquisitions. Has potential to make good Greenland measurements.

Backup Material


gfo.wfc00334-01155 : CAL2
Temp Corrected AGC(dB)
23.0
22.5
22.0
21.5
21.0
0
50
100
150
Days, from 2000-334T02:39:05.36 to 2001-156T00:47:14.14


gfo.wfc00334-01155 : CAL1
150
140
130
120
110
100
Calculated Height Correction(mm)
0
50
100
150
Days, from 2000-334T02:39:05.36 to 2001-156T00:47:14.14

Distribution of the 1- minute Segments over a 17- day Period



# of segments: 9726

Min segment length: 330.4248 km
Max segment length: 495.7234 km
Mean segment length: 398.1563 km

5^{th} order Butterworth filter
cutoff frequency of 0.30 Hz:

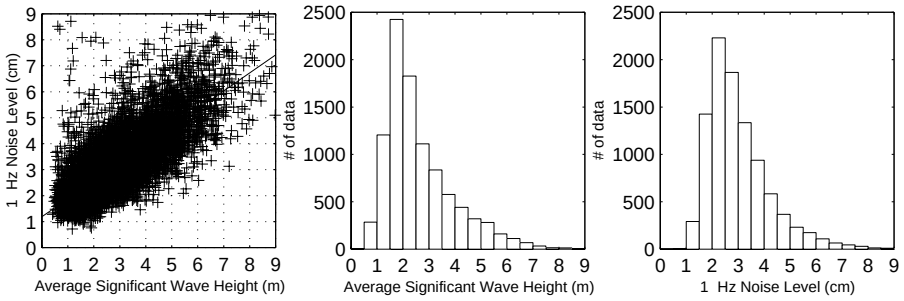
Slope (F,+): 0.69233± 0.011548
Intercept (F,+): 1.1871
R^2: 0.58683
Noise Level at 2m swh: 2.5717

Ku swh value distribution:

Mean: 2.6235
Std: 1.3162
Skewness: 1.2942
Kurtosis: 4.6346

Noise level value distribution:

Mean: 3.0034
Std: 1.1895
Skewness: 1.3517
Kurtosis: 5.3068



GFO Follow-On (GFO) Ground Processing Errors

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.
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.

GFO Follow-On (GFO) Ground Processing Errors (cont.)

Data Type	Data Date	Comments
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.
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.

GFO Follow-On (GFO) Ground Processing Errors (cont.)

Data Type	Data Date	Comments
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.
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.

GFO Follow-On (GFO) Ground Processing Errors (cont.)

Data Type	Data Date	Comments
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 125T08:55.
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.

GFO Follow-On (GFO) Key Events

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.
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	A Moon Intrusion affected GFO pointing. The maximum pointing error (ADNADER) was 0.55 degrees. Other intrusions at around this time may have occurred. None exceeded 0.27 degrees.

GFO Follow-On (GFO) Key Events

Event	Date & Time of Event	Comments
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.
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.

GFO Follow-On (GFO) Key Events

Event	Date & Time of Event	Comments
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	GFO maneuver. 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	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: 14:12:00 - 14:12:30Z (0.95 degrees max)
Moon Intrusion	05 Feb 2001 2001036T15:52:50Z	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: 15:52:50 - 15:53:10Z (0.47 degrees max)

GFO Follow-On (GFO) Key Events

Event	Date & Time of Event	Comments
Moon Intrusion	10 Feb 2001 2001041T06:30:00Z	GFO horizon scanner has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). The time of the excursion and maximum amplitude is: 04:32:25 - 04:32:40Z (0.35 degrees max)
Moon Intrusion	11 Feb 2001 2001042T13:47:05Z	GFO horizon scanner has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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.

GFO Follow-On (GFO) Key Events

Event	Date & Time of Event	Comment
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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). The time of the excursion and maximum amplitude is: 05:54:55Z - 05:55:05Z (0.40 degrees max)

GFO Follow-On (GFO) Key Events

Event	Date & Time of Event	Comments
Moon Intrusion	06 Mar 2001 2001065T19:52:45Z	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). The time of the excursion and maximum amplitude is: 09:13:40Z - 09:14:05Z (0.74 degrees max)
Moon Intrusion	12 Mar 2001 2001071T18:10:20Z	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). The time of the excursion and maximum amplitude is: 19:50:43Z - 19:51:10Z (0.59 degrees max)

GFO Follow-On (GFO) Key Events

Event	Date & Time of Event	Comments
Test Support	14 Mar 2001 2001073T21:48:30Z	Due to a Momentun 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 purpose of the maneuver will be to raise the semi-major axis and maintain the ERO. The burn magnitude will be 30.4 mm/sec with a zero degree yaw offset.
Trim Maneuver	30 Mar 2001 2001089T01:13:00Z	The purpose of the maneuver will be to raise the semi-major axis and maintain the ERO. The burn magnitude will be 36 mm/sec with a zero degree yaw offset.
Trim Maneuver	03 Apr 2001 2001093T00:51:00Z	The purpose of the maneuver will be to raise the semi-major axis and maintain the ERO. The next burn will be in 100 minutes.
Trim Maneuver	03 Apr 2001 2001093T02:31:00Z	The purpose of the maneuver will be to raise the semi-major axis and maintain the ERO. The total burn magnitude will be 70 mm/sec with a zero degree yaw offset.
Trim Maneuver	04 Apr 2001 2001094T03:22:00Z	The purpose of the maneuver will be to raise the semi-major axis and maintain the ERO. The burn magnitude will be 40 mm/sec with a 180 degree yaw offset.
Moon Intrusion	10 Apr 2001 2001100T19:53:33Z	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). The time of the excursion and maximum amplitude is: 21:33:50Z - 21:34:40Z (0.59 degrees max)

GFO Follow-On (GFO) Key Events

Event	Date & Time of Event	Comments
Moon Intrusion	10 Apr 2001 2001100T22:38:13Z	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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	GFO horizon scanner 2 has experienced a moon intrusion event which have caused excursions from acceptable nadir pointing limits (.27 degrees). 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 purpose of the maneuver will be to raise the semi-major axis and maintain the ERO. The burn magnitude will be 30 mm/sec with a 0 degree yaw offset.

GFO Follow-On (GFO) Key Events

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 intrepeted that as 6 days and 8.7 hours in the future from Day 116 or Day 123-124. (CSM commands can be uploaded a mximum of 6 days 8.7 hours before they execute.)
Trim Maneuver	02 May 2001 2001122T05:39:00Z	The purpose of the maneuver will be to raise the semi-major axis and maintain the ERO. The burn magnitude will be 30.9 mm/sec with a 0 degree yaw offset.
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.
Trim Maneuver	31 May 2001 2001151T23:49:00Z	The purpose of the maneuver will be to raise the semi-major axis and maintain the ERO. The burn magnitude will be 16.8 mm/sec with a 0 degree yaw offset.