An Analysis of Pipeline Wavelength Calibrations for the First-Order Gratings of the GHRS in Cycles 4 Through 6

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ABSTRACT

This Report is based on the execution of the Side 2 calibration proposals 5600, 6172 and 6898, and Side 1 calibration proposals 5542, 6171, and 6897 (Cycles 4, 5, and 6, respectively). Results indicate that the default wavelength scale provided by the pipeline data reduction system has not changed significantly with time during the past three cycles.

1. Introduction.

The behavior of the GHRS is monitored regularly via execution of calibration programs designed to test the characteristics of the instrument. One of the most important tests is the verification of the stability of the wavelength scales for the various gratings. Previous results for Side 2 first order gratings (G160M, G200M, and G270M) were discussed in ISR 52. This *Instrument Science Report* discusses new measurements for the gratings on both Side 1 and Side 2 for Cycles 4 to 6.

2. Calibration Methodology.

GHRS wavelength calibrations for the Side 2 first order gratings (G160M, G200M, and G270M) were executed as proposals 5600, 6172, and 6898 for Cycles 4, 5, and 6, respectively. Wavelength calibrations for the Side 1 first order gratings (G140L and G140M) were executed as proposals 5542, 6171, and 6897 for the same period. Several exposures at consistent central wavelengths were obtained. These proposals executed approximately every three months and were run internally with no on-target *HST* time (although the telescope is always pointed at the north ecliptic pole to avoid contaminating earth light).

3. Observations and Data Analysis.

Datasets for visits from all three cycles which were used in this analysis are listed in Table 1 (Side 1) and Table 2 (Side 2). Each visit typically represents observations taken at several different central wavelengths, i.e., 4 to 6 different carrousel positions (depending upon the cycle). Each exposure was an ACCUM using aperture SC2; a spectrum Y-balance was performed for each exposure. All data were calibrated using the **calhrs** software with the GWC_CORR switch set to PERFORM. DQI_CORR, DIO_CORR, MAP_CORR, MER_CORR, ADC_CORR, and IAC_CORR were also set to PERFORM. Some Cycle 2 data were also recalibrated with GWC_CORR set to PERFORM as a test verifying no significant systematic offsets had been introduced. The resulting spectra were then reduced with the task **zwavecal**.

How good is the wavelength scale used by the pipeline software, **calhrs**? One method of determining this is using the task **waveoff.** The task calculates the general zero-point offset between a calculated wavelength solution and a spectral observation of a calibration lamp for a given spectrum. The computed offset, determined in wavelength, pixel, and sample space, is useful in determining the “correctness” of the wavelength solution. Offsets have been determined for all spectra taken during Cycles 4 to 6 and are tabulated in Tables 3 and 4. The quality of fit for individual lines may be determined by examining the output of the task **zwaveid.** This task locates lines in GHRS wavelength observations and fits the wavelength solution equation producing a table of coefficients for the solution. A line is fit to the offsets (determined as a function of the predicted reference wavelengths) using the **gfit** task in order to determine intercepts and slopes for the spectra examined. The fits generated were based upon a second order legendre polynomial function, similar to that used in ISR 52 for the Cycle 2 wavelength calibration analysis. Points above and below two sigma from the mean were rejected, *cf.* Fig 1. Points rejected by the solution remain in the plot (identified as a diamond). The slope (a1) and *y*-intercept (a0) for each spectrum are also tabulated with the **waveoff** offsets in Table 3 (Side 1) and Table 4 (Side 2).

Finally, all observations for a given grating and cycle were merged into a single table and fit in the same manner as described above.

4. Discussion.

An examination of the offsets in Tables 3 and 4 demonstrate some cycle to cycle zero point shifts but the differences are generally very small. More dramatic shifts within the cycle (particularly in Cycle 4) are noted. This is also very graphically exhibited in the merged data for the Cycle 5 G140L data (*Fig 5*). The larger rms values for the G140L grating clearly represent the effect of merging the data for the entire cycle which contain the larger zero point shifts. Also, G140L may show greater sensitivity to temperature effects than the other gratings; this will be the subject of a future report. It is, therefore, very

important to use the wavelength calibration observations closest in time to a science data set to achieve the best solution. Tables 5 to 7 list the fit results of our measurements of the merged data for all first-order gratings by cycle. As before (ISR 052), we found that certain lines at each grating setting had consistently deviant positions relative to their reference wavelengths; these were ignored in our analysis. After doing so, we found rms scatter about a mean relation for the merged data to be that listed in the rms columns of Tables 4 to 7. Examples of the first order grating analyses of the merged data are shown in Figures 2 to 6 (Cycle 5 only). The rms scatter measures random error and may include a component of error in the laboratory wavelengths themselves.

The rms values in Tables 3 to 7 are determined around a fitted straight line and exhibit errors of only a few milli-Ångstroms. Typical errors are well within the specifications of the default wavelength scale as noted before in ISR 52 for the analysis of Cycle 2 Side 2 data. Rms values reported here are consistent with the Cycle 2 results, exhibiting values on the same order to within a few tenths of a milli-Ångstrom.

5. Summary.

Programs 5600, 6172, and 6898 (Side 2), 5542, 6171, and 6897 (Side 1) have monitored the stability of the wavelength scale for all the first-order gratings including G160M, G200M, and G270 (Side 2) and G140L and G140M (Side 1). [No observations were obtained during Cycle 4 with the Side 1 grating G140M.] Although some zero-point shifts are demonstrated within a given cycle for the G140L grating, in particular, the resulting analysis has shown that the wavelength solutions for these gratings are stable and remain well within specifications. Further analysis will be needed to determine if better corrections can be calculated for, e.g., temperature effects, and this is planned. The present report, however, is intended to complete the initial analysis of these observations.

Table 1: Side 1 Wavelength Monitor Observations

λ (Å)	G140L Cycle 4	G140L Cycle 5	G140L Cycle 6	G140M Cycle 5	G140M Cycle 6
1200	z2be0101t	z2u90601t	z3gy0601t	z2u90701t	z3gy0701t
	z2be0201t	z2u91601t	z3gy1601t	z2u91701t	z3gy1701t
	z2be0301t	z2u92601t		z2u92701t	
	z2be0401t				
	z2be5101t				
	z2be5201t				
	z2be5301t[a]				
	z2be5401t				
1400	z2be0102t	z2u90602t	z3gy0602t	z2u90702t	z3gy0702t
	z2be0202t	z2u91602t	z3gy1602t	z2u91702t[b]	z3gy1702t
	z2be0302t	z2u92602t		z2u92702t	
	z2be0402t				
	z2be5102t				
	z2be5202t				
	z2be5302t				
	z2be5402t				
1600	z2be0103t	z2u90603t	z3gy0603t	z2u90703t	z3gy0703t
	z2be0203t	z2u91603t	z3gy1603t	z2u91703t	z3gy1703t
	z2be0303t	z2u92603t		z2u92703t	
	z2be0403t				
	z2be5103t				
	z2be5203t				
	z2be5303t				
	z2be5403t				
1800	z2be0104t	z2u90604t	z3gy0604t	z2u90704t[c]	[d]
	z2be0204t	z2u91604t	z3gy1604t	z2u91704t	
	z2be0304t				
	z2be0404t				
	z2be5104t				
	z2be5204t				
	z2be5304t				
	z2be5404t				

a. Observation lost due to carrousel reset; only .shp file exists.
b. Exposure shortened by 25% due to carrousel reset.
c. Y-balance failure; low counts.
d. No Cycle 6 observations at 1800 Å were made.

Table 2: Side 2 Wavelength Monitor Observations

Grating	λ (Å)	Cycle 4	Cycle 5	Cycle 6
G160M	1240	z29p0101t	z2ud0601t	z2ud3601t
		z29p0201t	z2ud1601t	z3jy1601t
		z29p0301t	z2ud2601t	
		z29p0401t		
		z29p5101t		
	1400	z29p0102t	z2ud0602t	z2ud3602t
		z29p0202t	z2ud1602t	z3jy1602t
		z29p0302t	z2ud2602t	
		z29p0402t		
		z29p5102t		
	1520	z29p0103t	z2ud0603t	z2ud3603t
		z29p0203t	z2ud1603t	z3jy1603t
		z29p0303t	z2ud2603t	
		z29p0403t		
		z29p5103t		
	1640	z29p0104t	z2ud0604t	z2ud3604t
		z29p0204t	z2ud1604t	z3jy1604t
		z29p0304t	z2ud2604t	
		z29p0404t		
		z29p5104t		
	1780	z29p0105t	z2ud0605t	z2ud3605t
		z29p0205t	z2ud1605t	z3jy1605t
		z29p0305t	z2ud2605t	
		z20p0405t		
		z29p5105t		
	1940	z29p0106t	z2ud0701t	z2ud3701t
		z29p0206t	z2ud1701t	z3jy1701t
		z29p0306t	z2ud2701p	
		z29p0406t		
		z29p5106t		

Table 2: Side 2 Wavelength Monitor Observations (Continued)

Grating	λ (Å)	Cycle 4	Cycle 5	Cycle 6
G200M	1780	z29p0501t	z2ud0702t	z2ud3702t
		z29p0601t	z2ud1702t	z3jy1702t
		z29p0701t	z2ud2702t	
		z29p0801t		
		z29p5501t		
	1941	z29p0502t	z2ud0703t	z2ud3703t
		z29p0602t	z2ud1703t	z3jy1703t[a]
		z29p0702t	z2ud2703p	
		z29p0802t		
		z29p5502t		
	2101	z29p0503t	z2ud0704t	z2ud3704t
		z29p0603t	z2ud1704t	z3jy1704t
		z29p0703t	z2ud2704t	
		z29p0803t		
		z29p5503t		
	2240	z29p0504t	z2ud0705t	z2ud3705t
		z29p0604t	z2ud1705t	z3jy1705t
		z29p0704t	z2ud2705p	
		z29p0804t		
		z29p5504t		
	2381	z29p0505t		
		z29p0605t		
		z29p0705t		
		z29p0805t		
		z29p5505t		
	2500	z29p0506t		
		z29p0606t		
		z29p0706t		
		z29p0806t		
		z29p5506t		

Table 2: Side 2 Wavelength Monitor Observations (Continued)

Grating	λ (Å)	Cycle 4	Cycle 5	Cycle 6
G270M	2377	z29p0901t	z2ud0801t	z2ud3801t
		z29p0a01t	z2ud1801t	z3jy1801t
		z29p0b01t	z2ud2801p	
		z29p0c01t		
		z29p5901t		
	2500	z29p0902t	z2ud0802t	z2ud3802t
		z29p0a02t	z2ud1802t	z3jy1802t
		z29p0b02t	z2ud2802p	
		z29p0c02t		
		z29p5902t		
	2700	z29p0903t	z2ud0803t	z2ud3803t
		z29p0a03t	z2ud1803t	z3jy1803t
		z29p0b03t	z2ud2803t	
		z29p0c03t		
		z29p5903t		
	2901	z29p0904t	z2ud0804t	z2ud3804t
		z29p0a04t	z2ud1804t	z3jy1804t
		z29p0b04t	z2ud2804p	
		z29p0c04t		
		z29p5904t		
	3051	z29p0905t	z2ud0805t	z2ud3805t
		z29p0a05t	z2ud1805t	z3jy1805t
		z29p0b05t	z2ud2805t	
		z29p0c05t		
		z29p5905t		
	3200	z29p0906t	z2ud0806t	z2ud3806t
		z29p0a06t	z2ud1806t	z3jy1806t
		z29p0b06t	z2ud2806t	
		z29p0c06t		
		z29p5906t		

a. Data lost due to tape recorder track change.

Table 3: Side 1 - Wavelength Offsets, Zero-points, Y-Intercepts

rootname	Date	woffset (Å)	poffset (pixels)	RMS (mÅ)	y-intercept a(0)	slope a(1)
G140L - 1200 Å						
z3gy1601t	18 Nov 96	1.315	9.185	50.23	-1.756	3.346e-04
z3gy0601t	31 Aug 96	1.027	7.176	47.73	-1.609	4.641e-04
z2u92601t	04 May 96	0.597	4.172	50.06	-1.381	4.951e-04
z2u91601t	03 Jan 96	0.094	0.658	52.03	-0.179	6.402e-05
z2u90601t	13 Sep 95	0.334	2.330	49.45	-0.613	2.368e-04
z2be5401t	26 Jun 95	0.105	0.736	47.20	-0.406	2.113e-04
z2be5201t	18 Jun 95	0.360	2.515	51.75	-0.497	8.788e-05
z2be5101t	11 Jun 95	-0.179	-1.250	47.83	-0.223	3.135e-04
z2be0401t	10 Mar 95	0.596	4.164	47.32	-0.652	3.570e-05
z2be0301t	24 Nov 94	0.876	6.119	52.33	-0.988	5.258e-05
z2be0201t	09 Aug 94	0.048	0.335	38.70	-0.350	2.520e-04
z2be0101t	23 Apr 94	0.436	3.044	45.83	-0.563	8.408e-05
G140L - 1400 Å						
z3gy1602t	18 Nov 96	1.429	9.982	42.46	-1.448	2.339e-05
z3gy0602t	31 Aug 96	1.077	7.521	45.21	-1.263	1.160e-04
z2u92602t	04 May 96	1.172	8.187	46.85	-1.028	1.263e-04
z2u91602t	03 Jan 96	0.150	1.049	44.69	0.013	-1.262e-04
z2u90602t	13 Sep 95	0.421	2.941	38.72	-0.100	-2.004e-04
z2be5402t	26 Jun 95	0.213	1.484	43.62	-0.076	-8.662e-05
z2be5302t	20 Jun 95	0.065	0.456	47.74	0.080	-8.864e-05
z2be5202t	18 Jun 95	0.435	3.033	41.82	-0.322	-1.107e-04
z2be5102t	11 Jun 95	-0.136	-0.946	41.63	0.256	-9.458e-05
z2be0402t	10 Mar 95	0.685	4.784	42.34	-0.587	-6.371e-05
z2be0302t	24 Nov 94	1.003	7.003	44.30	-0.606	-2.586e-04
z2be0202t	09 Aug 94	0.121	0.842	43.61	0.024	-8.777e-05
z2be0102t	23 Apr 94	0.501	3.497	44.06	-0.219	-2.103e-04
G140L - 1600 Å						
z3gy1603t	18 Nov 96	1.351	9.430	45.45	-1.174	-1.201e-04
z3gy0603t	31 Aug 96	1.022	7.135	44.78	-1.095	6.514e-05
z2u92603t	04 May 96	0.966	6.741	41.65	-0.841	5.936e-05
z2u91603t	03 Jan 96	0.064	0.445	40.33	0.263	-2.257e-04
z2u90603t	13 Sep 95	0.318	2.222	42.48	0.062	-2.415e-04
z2be5403t	26 Jun 95	-0.120	0.837	52.32	0.221	-2.018e-04
z2be5303t	20 Jun 95	-0.092	-0.645	50.18	0.481	-2.583e-04
z2be5203t	18 Jun 95	0.412	2.872	51.77	0.093	-3.142e-04
z2be5103t	11 Jun 95	-0.189	-1.319	44.97	0.672	-2.919e-04
z2be0403t	10 Mar 95	0.545	3.802	45.99	-0.080	-3.155e-04

Table 3: Side 1 - Wavelength Offsets, Zero-points, Y-Intercepts

rootname	Date	woffset (Å)	poffset (pixels)	RMS (mÅ)	y-intercept a(0)	slope a(1)
z2be0303t	24 Nov 94	0.864	6.030	41.09	-0.192	-4.385e-04
z2be0203t	09 Aug 94	-0.032	-0.224	41.19	0.323	-2.041e-04
z2be0103t	23 Apr 94	0.430	2.998	46.08	0.049	-2.978e-04
G140L - 1800 Å						
z3gy1604t	18 Nov 96	1.325	9.245	51.10	-1.507	1.247e-04
z3gy0604t	31 Aug 96	0.860	5.999	55.92	-1.535	3.804e-04
z2u91604t	03 Jan 96	0.028	0.192	45.74	0.181	1.012e-02
z2u90604t	13 Sep 95	0.182	1.271	45.90	-0.462	1.587e-04
z2be5404t	26 Jun 95	-0.001	-0.010	42.18	0.050	-3.015e-05
z2be5304t	20 Jun 95	-0.137	-0.955	38.01	0.007	9.815e-05
z2be5204t	18 Jun 95	0.284	1.978	42.58	-0.439	7.863e-05
z2be5104t	11 Jun 95	-0.289	-2.016	42.78	-0.156	2.487e-04
z2be0404t	10 Mar 95	0.512	3.566	42.64	-0.617	8.329e-05
z2be0304t	24 Nov 94	0.770	5.371	38.61	-0.891	6.184e-05
z2be0204t	09 Aug 94	-0.088	-0.614	35.39	-0.185	1.667e-04
z2be0104t	23 Apr 94	0.327	2.279	47.16	-0.437	6.353e-05
G140M - 1200 Å						
z3gy1701t	25 Nov 96	-0.029	-2.111	1.53	0.154	-1.044e-04
z3gy0701t	31 Aug 96	-0.003	-0.232	0.99	0.085	-6.579e-05
z2u92701t	04 May 96	-0.018	-1.276	1.21	0.231	-1.760e-04
z2u91701t	04 Jan 96	-0.065	-4.641	3.36	0.376	-2.576e-04
z2u90701t	15 Sep 95	-0.037	-2.632	5.51	-0.018	4.531e-05
G140M - 1400 Å						
z3gy1702t	25 Nov 96	-0.010	-0.705	2.12	0.129	-7.966e-05
z3gy0702t	31 Aug 96	-0.005	-0.396	1.70	0.220	-1.493e-04
z2u92702t	04 May 96	-0.015	-1.107	2.01	0.280	-1.834e-04
z2u91702t	04 Jan 96	-0.057	-4.129	3.49	0.176	-8.354e-05
z2u90702t	15 Sep 95	-0.032	-2.371	4.73	0.324	-2.081e-04
G140M - 1600 Å						
z3gy1703t	25 Nov 96	-0.016	-1.229	3.20	-0.247	1.617e-04
z3gy0703t	31 Aug 96	-0.016	-1.229	2.44	0.154	-8.524e-05
z2u92703t	04 May 96	-0.025	-1.853	2.26	0.298	1.731e-04
z2u91703t	04 Jan 96	-0.057	-4.257	4.91	0.519	-2.873e-04
z2u90703t	15 Sep 95	-0.036	-2.659	4.26	0.393	-2.228e-04
G140M - 1800 Å						
z2u91704t	04 Jan 96	-0.042	-3.273	single line in solution		
z2u90704t	15 Sep 95	-0.027	-2.114			

Table 4: Side 2 - Wavelength Offsets, Zero-points, Y-Intercepts

rootname	Date	woffset (Å)	poffset (pixels)	RMS (mÅ)	y-intercept a(0)	slope a(1)
G160M - 1240 Å						
z3jy1601t	23 Nov 96	0.016	0.875	3.12	-0.121	8.400e-05
z2ud3601t	26 Aug 96	-0.016	-0.856	2.63	-0.099	8.658e-05
z2ud2601t	29 Apr 96	0.002	0.116	2.92	0.020	-2.057e-05
z2ud1601t	06 Jan 96	-0.011	-0.594	3.83	-0.317	2.657e-04
z2ud0601t	13 Sep 95	0.018	1.006	3.20	-0.165	1.202e-04
z29p5101t	07 May 95	0.002	0.118	2.67	-0.366	2.897e-04
z29p0401t	14 Feb 95	-0.013	-0.714	2.69	-0.013	1.667e-05
z29p0301t	27 Nov 94	-0.008	-0.434	3.26	-0.161	1.309e-04
z29p0201t	20 Dec 94	-0.006	-0.344	3.55	-0.208	1.675e-04
z29p0101t	26 Mar 94	0.004	0.245	3.48	-0.117	8.986e-05
G160M - 1400 Å						
z3jy1602t	23 Nov 96	0.004	0.208	4.33	-0.005	-3.119e-06
z2ud3602t	26 Aug 96	-0.023	-1.286	3.59	0.183	-1.151e-04
z2ud2602t	29 Apr 96	0.004	0.238	5.25	0.148	-1.113e-04
z2ud1602t	06 Jan 96	-0.013	-0.726	3.50	-0.171	1.366e-04
z2ud0602t	13 Sep 95	0.016	0.900	4.14	0.222	-1.616e-04
z29p5102t	07 May 95	-0.003	-0.185	2.78	0.011	-2.454e-06
z29p0402t	14 Feb 95	-0.017	-0.976	3.10	0.026	-5.363e-06
z29p0302t	27 Nov 94	-0.012	-0.675	4.06	0.118	-7.505e-05
z29p0202t	20 Dec 94	-0.016	-0.881	3.05	-0.270	1.996e-04
z29p0102t	26 Mar 94	-0.002	-0.089	4.61	0.159	-1.069e-04
G160M - 1520 Å						
z3jy1603t	23 Nov 96	-0.013	-0.713	4.32	0.457	-2.971e-04
z2ud3603t	26 Aug 96	-0.020	-1.154	3.03	0.049	-1.709e-04
z2ud2603t	29 Apr 96	0.012	0.691	3.02	0.406	-2.741e-04
z2ud1603t	06 Jan 96	-0.026	-1.465	3.54	0.018	5.431e-06
z2ud0603t	13 Sep 95	0.003	0.016	3.10	0.203	-1.329e-04
z29p5103t	07 May 95	-0.019	-1.072	3.30	-0.004	1.130e-05
z29p0403t	14 Feb 95	-0.027	-1.539	3.82	0.168	-9.861e-05
z29p0303t	27 Nov 94	-0.027	-1.509	3.41	0.166	-9.772e-05
z29p0203t	20 Dec 94	-0.011	-0.645	3.94	0.106	-5.964e-05
z29p0103t	26 Mar 94	-0.017	-0.967	4.14	0.219	-1.350e-04
G160M - 1640 Å						
z3jy1604t	23 Nov 96	-0.003	-0.146	3.20	0.217	-1.315e-04
z2ud3604t	26 Aug 96	-0.008	-0.439	3.93	0.267	-1.568e-04
z2ud2604t	29 Apr 96	0.020	1.140	3.56	0.100	-7.245e-05
z2ud1604t	06 Jan 96	-0.013	-0.728	2.05	-0.209	1.385e-04

Table 4: Side 2 - Wavelength Offsets, Zero-points, Y-Intercepts

rootname	Date	woffset (Å)	poffset (pixels)	RMS (mÅ)	y-intercept a(0)	slope a(1)
z2ud0604t	13 Sep 95	0.004	0.237	3.04	0.225	-1.388e-04
z29p5104t	07 May 95	-0.010	-0.555	4.00	-0.047	3.273e-05
z29p0404t	14 Feb 95	-0.005	-0.293	4.23	0.378	-2.260e-04
z29p0304t	27 Nov 94	-0.008	-0.439	4.70	0.233	-1.349e-04
z29p0204t	20 Dec 94	-0.002	-0.086	4.05	0.348	-2.075e-04
z29p0104t	26 Mar 94	-0.003	-0.197	3.38	-0.062	4.097e-05
G160M - 1780 Å						
z3jy1605t	23 Nov 96	-0.009	-0.507	3.04	0.126	-6.692e-05
z2ud3605t	26 Aug 96	-0.018	-1.037	1.86	0.157	-8.170e-05
z2ud2605t	29 Apr 96	-0.003	-0.155	4.11	0.475	-2.686e-04
z2ud1605t	06 Jan 96	-0.023	-1.315	3.89	0.067	-2.207e-05
z2ud0605t	13 Sep 95	-0.023	-1.334	3.70	0.491	-2.672e-04
z29p5105t	07 May 95	-0.021	-1.232	2.73	-0.407	2.406e-04
z29p0405t	14 Feb 95	-0.020	-1.168	4.44	0.316	-1.688e-04
z29p0305t	27 Nov 94	-0.025	-1.479	4.07	0.644	-3.494e-04
z29p0205t	20 Dec 94	-0.026	-1.528	3.64	0.095	-4.259e-05
z29p0105t	26 Mar 94	-0.019	-1.079	1.86	0.607	-3.297e-04
G160M - 1940 Å						
z3jy1701t	24 Nov 96	-0.002	-0.144	2.31	-0.584	3.054e-04
z2ud3701t	26 Aug 96	-0.006	-0.346	3.07	-0.379	1.995e-04
z2ud2701p	29 Apr 96	0.012	0.711	2.57	-0.545	2.754e-04
z2ud1701t	19 Jan 96	-0.005	-0.288	4.01	-0.510	2.666e-04
z2ud0701t	13 Sep 95	0.006	0.384	2.71	-0.269	1.364e-04
z29p5106t	07 May 95	-0.013	-0.792	2.36	-0.815	4.285e-04
z29p0406t	14 Feb 95	-0.011	-0.664	2.93	-0.360	1.908e-04
z29p0306t	27 Nov 94	-0.017	-1.026	4.00	-0.382	2.058e-04
z29p0206t	20 Dec 94	-0.013	-0.797	2.91	-0.810	4.253e-04
z29p0106t	26 Mar 94	-0.012	-0.703	3.08	-0.079	4.794e-05
G200M - 1780 Å						
z3jy1702t	24 Nov 96	-0.123	-6.073	3.89	-0.227	1.984e-04
z2ud3702t	26 Aug 96	-0.012	-0.610	3.25	-0.025	2.141e-05
z2ud2702t	29 Apr 96	-0.019	-0.963	2.45	-0.440	2.591e-04
z2ud1702t	19 Jan 96	-0.079	-3.915	4.65	0.096	-8.289e-06
z2ud0702t	13 Sep 95	-0.043	-2.103	3.29	0.263	-1.259e-04
z29p5501t	06 May 95	-0.037	-1.806	2.27	0.184	-8.434e-05
z29p0801t	10 Feb 95	-0.101	-4.992	6.42	-0.102	1.138e-04
z29p0701t	21 Oct 94	0.009	0.426	3.97	-0.131	6.980e-05
z29p0601t	03 Jul 94	-0.034	-1.697	4.29	-0.347	2.096e-04
z29p0501t	18 Mar 94	-0.067	-3.327	3.81	0.051	4.415e-06
G200M - 1940 Å						

Table 4: Side 2 - Wavelength Offsets, Zero-points, Y-Intercepts

rootname	Date	woffset (Å)	poffset (pixels)	RMS (mÅ)	y-intercept a(0)	slope a(1)
z3jy1703t	failed					
z2ud3703t	26 Aug 96	-0.012	-0.610	2.69	-0.340	1.814e-04
z2ud2703p	29 Apr 96	-0.025	-1.259	3.12	-0.699	3.715e-04
z2ud1703t	19 Jan 96	-0.075	-3.769	5.73	-0.233	1.590e-04
z2ud0703t	13 Sep 95	-0.025	-1.274	2.30	-0.369	2.070e-04
z29p5502t	06 May 95	-0.026	-1.290	4.94	-0.263	1.487e-04
z29p0802t	10 Feb 95	-0.091	-4.541	4.18	-0.137	1.177e-04
z29p0702t	21 Oct 94	0.015	0.766	1.70	-0.254	1.240e-04
z29p0602t	03 Jul 94	-0.016	-0.791	3.16	-0.547	2.925e-04
z29p0502t	18 Mar 94	-0.061	-3.042	5.12	-0.509	2.908e-04
G200M - 2100 Å						
z3jy1704t	24 Nov 96	-0.115	-5.877	4.13	0.309	-9.283e-05
z2ud3704t	26 Aug 96	-0.029	-1.487	2.57	0.198	-8.150e-05
z2ud2704t	29 Apr 96	-0.026	-1.345	2.93	-0.246	1.305e-04
z2ud1704t	19 Jan 96	-0.087	-4.421	3.70	0.143	-2.770e-04
z2ud0704t	13 Sep 95	-0.040	-2.054	2.48	0.379	-1.617e-04
z29p5503t	06 May 95	-0.035	-1.796	2.98	0.337	-1.450e-04
z29p0803t	10 Feb 95	-0.099	-5.039	2.00	0.285	-8.889e-05
z29p0703t	21 Oct 94	0.006	0.029	2.35	0.452	-2.163e-04
z29p0603t	03 Jul 94	-0.031	-1.593	2.32	0.302	-1.285e-04
z29p0503t	18 Mar 94	-0.057	-2.890	2.51	0.394	-1.605e-04
G200M - 2240 Å						
z3jy1705t	24 Nov 96	-0.099	-5.114	3.19	0.153	-2.289e-05
z2ud3705t	26 Aug 96	-0.020	-1.059	4.59	-0.060	3.769e-05
z2ud2705p	29 Apr 96	-0.025	-1.271	3.22	-0.162	8.128e-05
z2ud1705t	19 Jan 96	-0.076	-3.926	3.14	0.667	-2.629e-04
z2ud0705t	13 Sep 95	-0.017	-0.869	2.97	0.456	-1.953e-04
z29p5504t	06 May 95	-0.023	-1.200	2.08	0.453	-1.909e-04
z29p0804t	10 Feb 95	-0.085	-4.384	2.49	0.847	-3.375e-04
z29p0704t	21 Oct 94	0.010	0.515	2.42	0.431	-1.955e-04
z29p0604t	03 Jul 94	-0.035	-1.808	4.24	-0.037	2.988e-05
z29p0504t	18 Mar 94	-0.052	-2.670	2.99	0.484	-1.947e-04
G200M - 2380 Å						
z29p5505t	06 May 95	-0.035	-1.847	3.89	0.417	-1.615e-04
z29p0805t	10 Feb 95	-0.095	-4.987	2.74	-0.075	7.190e-05
z29p0705t	21 Oct 94	0.006	0.034	3.32	1.013	-4.241e-04
z29p0605t	03 Jul 94	-0.050	-2.644	2.34	0.286	-1.014e-04
z29p0505t	18 Mar 94	-0.062	-3.245	3.18	0.007	2.023e-05
G200M - 2500 Å						
z29p5506t	06 May 95	-0.011	-0.609	4.68	-0.875	3.551e-04

Table 4: Side 2 - Wavelength Offsets, Zero-points, Y-Intercepts

rootname	Date	woffset (Å)	poffset (pixels)	RMS (mÅ)	y-intercept a(0)	slope a(1)
z29p0806t	10 Feb 95	-0.071	-3.799	2.99	-0.844	3.684e-04
z29p0706t	21 Oct 94	0.020	1.068	3.82	-1.218	4.817e-04
z29p0606t	03 Jul 94	-0.034	-1.810	2.85	-1.025	4.224e-04
z29p0506t	18 Mar 94	-0.035	-1.905	6.33	-1.196	4.921e-04
G270M - 2375 Å						
z3jy1801t	24 Nov 96	-0.036	-1.492	4.68	0.020	1.014e-05
z2ud3801t	27 Aug 96	-0.033	-1.382	3.20	0.078	-1.439e-05
z2ud2801p	29 Apr 96	-0.010	-0.399	2.58	-0.629	2.711e-04
z2ud1801t	19 Jan 96	-0.001	-0.039	3.77	-0.342	1.488e-04
z2ud0801t	13 Sep 95	0.004	0.185	3.84	0.226	-9.728e-05
z29p5901t	02 May 95	-0.002	-0.084	3.51	-0.077	3.352e-05
z29p0c01t	07 Feb 95	-0.013	-0.546	3.22	-1.002	3.170e-04
z29p0b01t	18 Oct 94	0.016	0.664	3.15	-2.935	9.155e-04
z29p0a01t	03 Jul 94	0.043	1.812	4.76	-2.434	7.556e-04
z29p0901t	18 Mar 94	0.025	1.045	3.13	-0.895	2.716e-04
G270M - 2500 Å						
z3jy1802t	24 Nov 96	-0.071	-3.022	3.86	-0.359	1.699e-04
z2ud3802t	27 Aug 96	-0.045	-1.899	3.41	-0.266	1.224e-04
z2ud2802p	29 Apr 96	-0.005	-0.217	2.32	-0.651	2.671e-04
z2ud1802t	19 Jan 96	-0.010	-0.410	2.60	-0.178	7.559e-05
z2ud0802t	13 Sep 95	0.007	0.310	2.88	0.481	-1.932e-04
z29p5902t	02 May 95	0.004	0.190	2.35	-0.250	9.980e-05
z29p0c02t	07 Feb 95	-0.004	-0.180	4.27	0.115	-4.436e-05
z29p0b02t	18 Oct 94	0.016	0.661	3.31	-0.481	1.952e-04
z29p0a02t	03 Jul 94	0.032	1.357	3.12	-0.414	1.591e-04
z29p0902t	18 Mar 94	0.033	1.381	3.05	-0.450	1.793e-04
G270M - 2700 Å						
z3jy1803t	24 Nov 96	-0.092	-3.991	5.45	0.749	-2.434e-04
z2ud3803t	27 Aug 96	-0.059	-2.541	4.01	0.229	-6.331e-05
z2ud2803t	29 Apr 96	-0.040	-1.723	4.76	0.222	-6.706e-05
z2ud1803t	19 Jan 96	-0.027	-1.158	6.43	0.516	-1.778e-04
z2ud0803t	13 Sep 95	-0.027	-1.186	5.48	1.104	-3.983e-04
z29p5903tt	02 May 95	-0.017	-0.748	5.69	0.979	-3.544e-04
z29p0c03t	07 Feb 95	-0.028	-1.220	3.98	0.095	-3.444e-05
z29p0b03t	18 Oct 94	-0.015	-0.641	2.73	-0.147	5.383e-05
z29p0a03t	03 Jul 94	0.018	0.774	2.68	-0.240	8.188e-05
z29p0903t	18 Mar 94	0.015	0.669	3.66	-0.620	2.376e-04
G270M - 2900 Å						
z3jy1804t	24 Nov 96	-0.085	-3.738	3.71	-0.084	5.688e-05
z2ud3804t	27 Aug 96	-0.051	-2.242	2.80	-0.213	9.022e-05

Table 4: Side 2 - Wavelength Offsets, Zero-points, Y-Intercepts

rootname	Date	woffset (Å)	poffset (pixels)	RMS (mÅ)	y-intercept a(0)	slope a(1)
z2ud2804p	29 Apr 96	-0.044	-1.941	1.96	-0.431	1.612e-04
z2ud1804t	19 Jan 96	-0.027	-1.186	3.24	-0.104	4.691e-05
z2ud0804t	13 Sep 95	-0.041	-1.772	2.84	0.916	-3.044e-04
z29p5904tt	02 May 95	-0.009	-0.393	2.44	0.005	3.020e-06
z29p0c04t	07 Feb 95	-0.041	-1.794	4.36	0.997	-3.570e-04
z29p0b04t	18 Oct 94	-0.007	-0.324	7.81	0.249	-8.828e-05
z29p0a04t	03 Jul 94	0.007	0.294	3.98	0.751	-2.818e-04
z29p0904t	18 Mar 94	0.017	0.737	6.15	-0.053	1.691e-05
G270M - 3050 Å						
z3jy1805t	24 Nov 96	-0.089	-3.998	3.80	0.136	-1.706e-05
z2ud3805t	27 Aug 96	-0.049	-2.219	2.16	0.196	-4.962e-05
z2ud2805t	29 Apr 96	-0.032	-1.454	3.76	0.115	-2.564e-05
z2ud1805t	19 Jan 96	-0.037	-1.662	3.86	0.640	-1.982e-04
z2ud0805t	13 Sep 95	-0.045	-2.011	2.79	0.926	-2.900e-04
z29p5905tt	02 May 95	-0.027	-1.208	2.01	0.544	-1.723e-04
z29p0c05t	07 Feb 95	-0.039	-1.759	3.42	0.326	-1.023e-04
z29p0b05t	18 Oct 94	-0.019	-0.833	3.01	-0.244	8.967e-05
z29p0a05t	03 Jul 94	-0.006	-0.259	3.42	0.123	-4.330e-05
z29p0905t	18 Mar 94	0.005	0.202	2.11	-0.584	1.986e-04
G270M - 3200 Å						
z3jy1806t	24 Nov 96	-0.067	-3.055	4.44	-1.841	5.956e-04
z2ud3806t	27 Aug 96	-0.013	-0.575	1.48	-2.047	6.430e-04
z2ud2806t	29 Apr 96	-0.010	-0.465	1.69	-2.240	7.024e-04
z2ud1806t	19 Jan 96	-0.014	-0.645	2.24	-2.290	7.177e-04
z2ud0806t	13 Sep 95	-0.017	-0.781	4.03	-1.753	5.541e-04
z29p5906t	02 May 95	0.004	0.177	2.57	-0.253	7.830e-05
z29p0c06t	07 Feb 95	-0.009	-0.414	4.15	0.759	-2.377e-04
z29p0b06t	18 Oct 94	0.006	0.029	2.48	0.075	-1.809e-05
z29p0a06t	03 Jul 94	0.008	0.382	2.42	0.316	-1.021e-04
z29p0906t	18 Mar 94	0.024	1.079	3.17	0.0262	-1.007e-05

Table 5: Results of Merged Measurements - Cycle 4

Grating	**N(pts)**	**RMS scatter (mÅ)**	y-intercept a(0)	**slope a(1)**
G140L	3998	326.87	-0.772	3.400e-04
G160M	1500	6.69	-0.016	1.745e-05
G200M	926	32.79	0.084	-2.106e-05
G270M	733	16.11	-0.098	3.602e-05

Table 6: Results of Merged Measurements - Cycle 5

Grating	**N(pts)**	**RMS scatter (mÅ)**	**y-intercept a(0)**	**slope a(1)**
G140L	1463	281.11	-0.930	3.789e-04
G140M	272	16.67	0.070	-2.485e-05
G160M	740	14.39	-0.032	2.347e-05
G200M	548	29.76	-0.011	2.171e-05
G270M	396	7.47	-0.107	4.787e-05

Table 7: Results of Merged Measurements - Cycle 6

Grating	**N(pts)**	**RMS scatter (mÅ)**	**y-intercept a(0)**	**slope a(1)**
G140L	1058	194.24	-1.484	2.012e-04
G140M	252	4.52	-0.013	1.857e-05
G160M	613	10.82	-0.013	1.218e-05
G200M	249	48.69	0.064	-8.401e-07
G270M	301	15.18	-0.019	2.843e-05

Figure 1: Example of Cycle 6 G160M gfit plot.

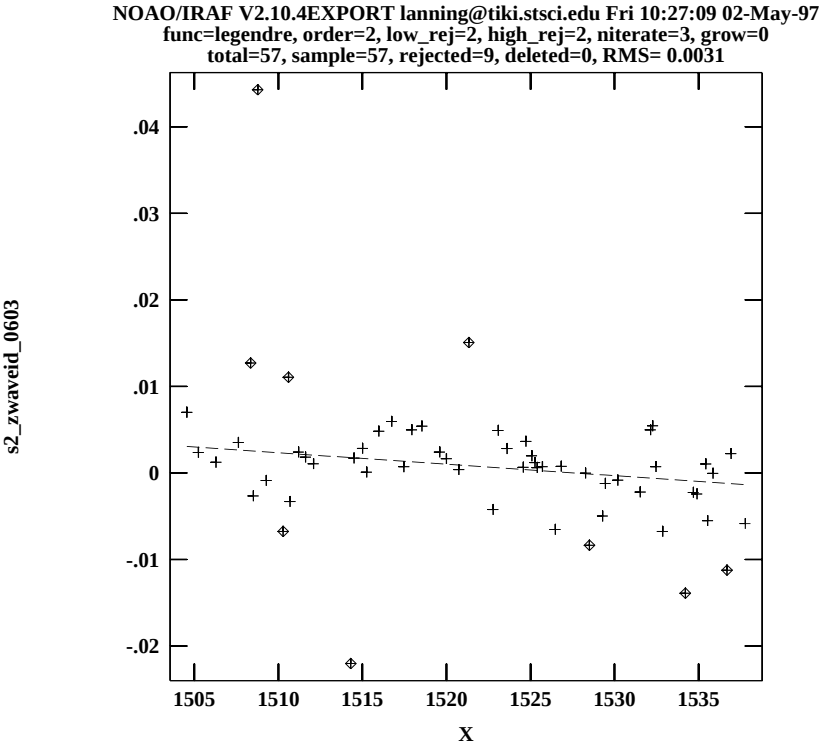

Figure 2: G160M Merged Data (Cycle 5).

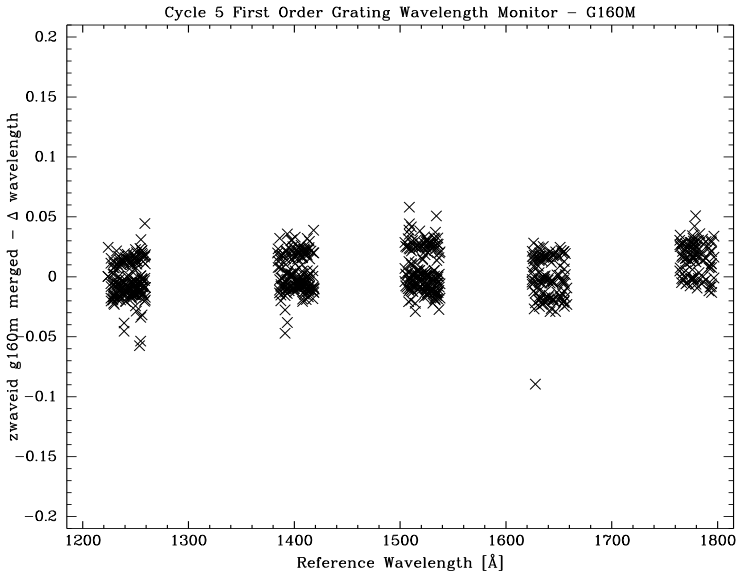

Figure 3: G200M Merged Data (Cycle 5).

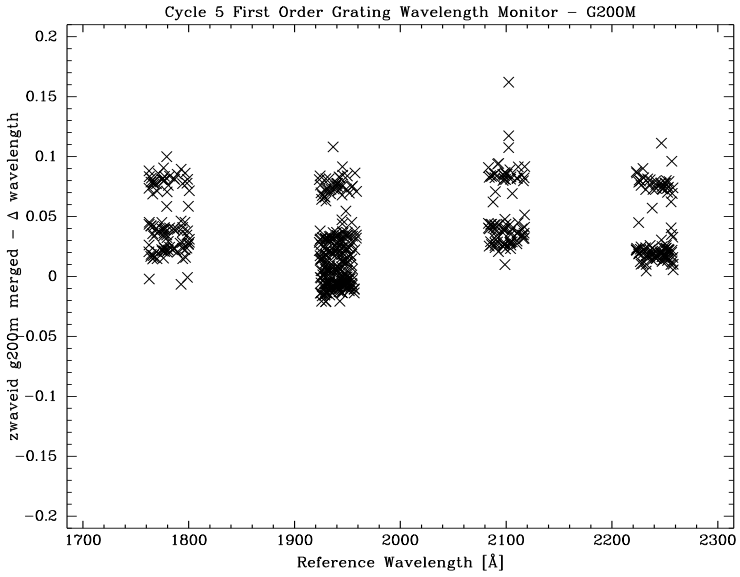

Figure 4: G270M Merged Data (Cycle 5).

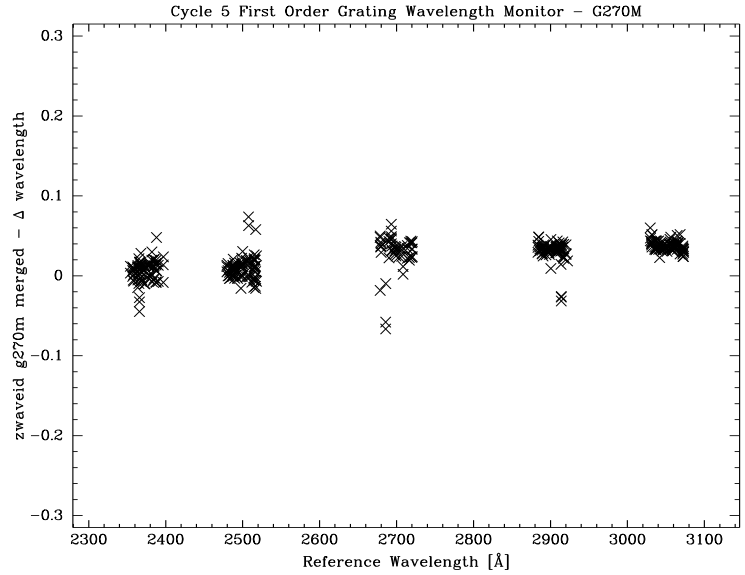

Figure 5: G140L Merged Data (Cycle 5). The open triangles represent the program execution on May 4, 1996, the solid triangles are for September 13, 1995, and the crosses are for January 3, 1996.

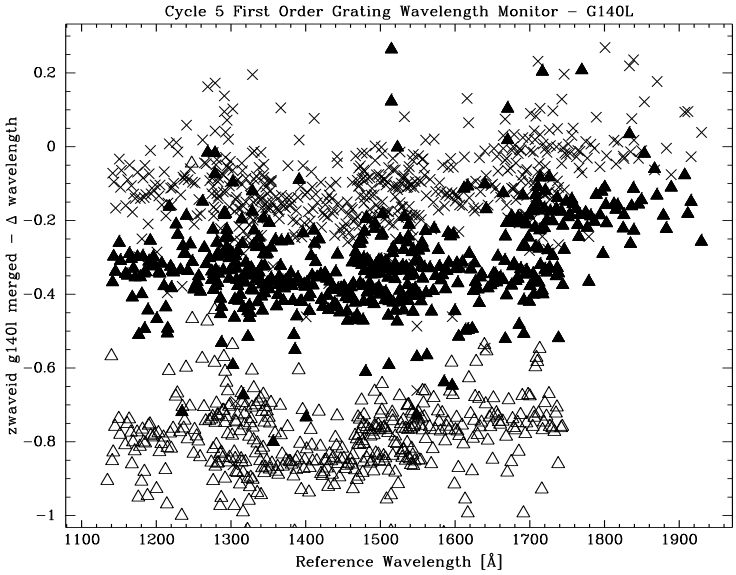

Figure 6: G140M Merged Data (Cycle 5).