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Final reprocessing of GHRS data

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Abstract
The report describes the final calibration of GHRS data made by CADC, ST-ECF and STScI. The data products can be accessed at the three datacenters MAST, CADC and ST-ECF.

1. Introduction

At the annual HST archive coordination meeting in 2003, the CADC, in collaboration with STScI, decided to produce the final calibration files for the science observations[1] made with the HRS and the FOC generation 1 instruments. In 2005, after successfully recalibrating the science data, it was decided to add the non-science data.

The general motivation was threefold: First, it was obvious that no changes were occurring for these instruments for both calibration files and calibration software. Second, because of the lack of maintenance for the calibration software -- the original instrument team members are gone or busy supporting other instruments – we were facing the danger of losing the capability to recalibrate the data in the near future. And third, the data was calibrated shortly after it was taken with sometimes not optimum reference files. On The Fly Reprocessing (OTFR) was never available for GHRS and so the files in the Archive were static and did not get reprocessed as better reference files came along later in the mission. We wanted to process the entire GHRS holding with a consistent set of reference files representing now the best calibration.

[1] The exclusion criteria for the science observations are listed in the appendix.

2. The first version

CADC reprocessed the GHRS data and initially 2 datasets were chosen to compare the newly calibrated data to the archived data (retrieved from the MAST): z3kz0107t and z23l0209t.

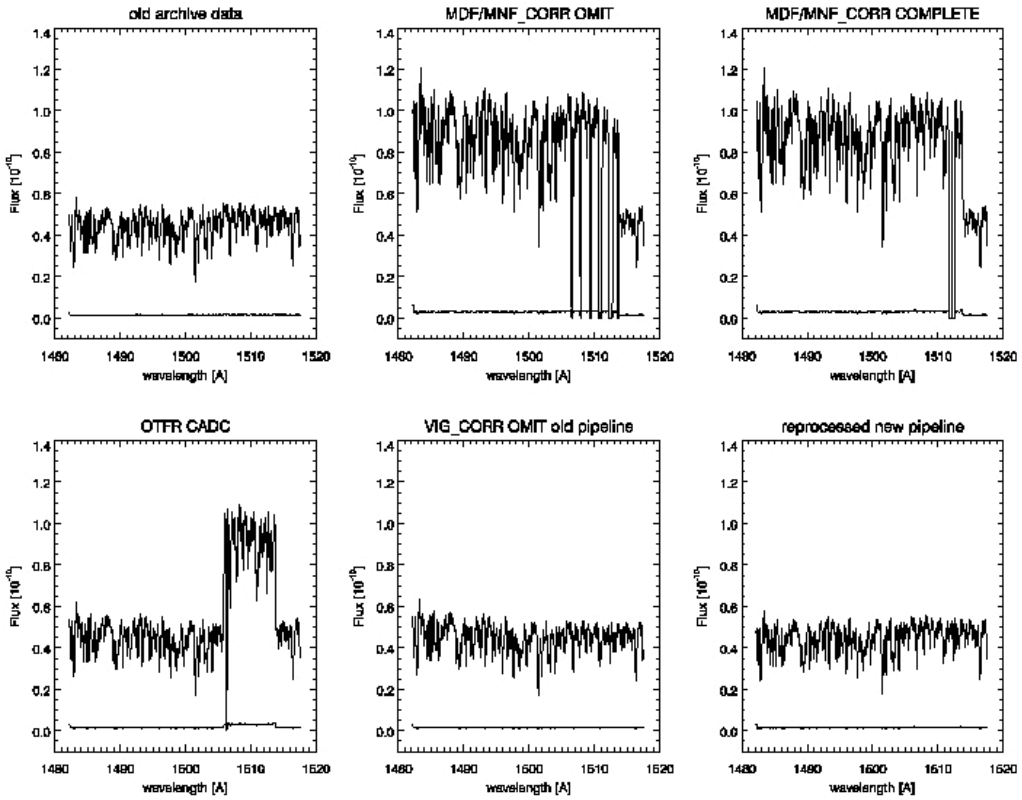

Figure 1: Different attempts of processing one particular dataset, z23l0209t. Shown is the old Archive data as well as different processing attempts by CADC and MAST. The last spectrum shows the final reprocessed product with the new pipeline software.

The data showed several suspicious flux jumps up and down (see Fig.1). A detailed comparison of the FITS keywords revealed that MDF_CORR (median filter of background spectra) and MNF_CORR (mean filter of background spectra) were set to PERFORM in the reprocessed version instead of OMIT in the old Archive version. Apart from that, the calibration files had not changed.

To look into the flux-jump problem further, the test sample was expanded and scrutinized for systematics, e.g. if only a particular grating was affected. Table 1 contains the list of dataset names for the comparison.

Table 1: Names of the datasets selected for comparison.

Dataset name	**Dataset name**	**Dataset name**
z33m010bt	z0zi0311t	z3ej010ct
z3g2510lt	z3kz010ct	z23l020et
z0zi0321m	z23l0209t	z0yl010bm
z18o0302t	z3kz0107t	

Seven out of the 11 chosen datasets show jumps or distortions that are most likely artificial and introduced by the processing step. Alberto Micol at ECF and Charles Proffitt at STScI processed the same datasets again and got inconsistent results or even floating point errors. The problem was reported to SSB and they traced it back to a bug in IRAF. The bug was then reported to NOAO.

Paul Barrett worked on this problem for SSB and he found the problem to be in the reading of certain files. He recommended to process the data with VIG_CORR set to OMIT. The error is apparently in an STSDAS IO library. When the vignetting calibration file is read, a routine first reads one data group in the GEIS file and then moves backward to read another group. During this sequence the data in the second group is corrupted.

A google search for this type of error in GHRS data returned the following webpage http://www.stsci.edu/ftp/instrument_news/GHRS/Ghrs_advisory/ghrs_spikes.html (Fig.2). Apparently this error was already documented in 1996 and got forgotten over time. Now even more gratings and a larger number of datasets seem to be affected.

A preliminary reprocessing of two datasets (z23l0209t and z3kz0107t) without removal of vignetting nonuniformity (VIG_CORR OMIT) showed spectra that are free of any jumps and that reproduce the same flux level as the old Archive datasets (see Fig.1).

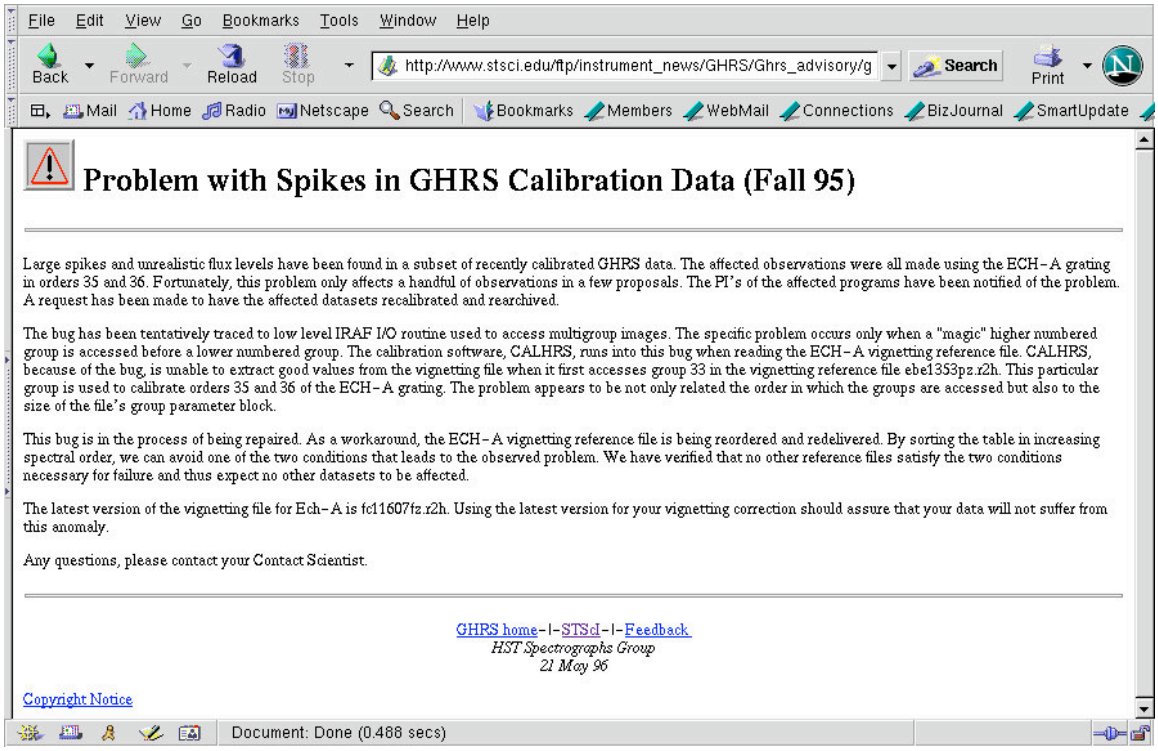

Figure 2: 1996 GHRS problem report

2. The final version

SSB provided a bugfix for calhrs. The work around is to read sequentially the entire GEIS file, storing the calibration information in an array for later use. CADC installed it and reran the processing of all science GHRS datasets. After our successful implementation and testing, the bugfix is distributed with the new version of calhrs (1.3.14) to the general community. This problem with sequential reading of GEIS files does not show up in the calibration of FOS or STIS data. Fig.1 illustrates the evolution of one particular dataset as we worked towards the solution of this software problem. We include this figure to illustrate the nature of the artifacts we encountered and the random nature of these artifacts.

2.1 Flux and wavelength calibration

The typical changes in calibrated fluxes for selected datasets are less than 10%. If fluxes are weak (<~1.e-12 erg/cm^2/s/A) or line cores are dark, the change in flux can be much larger. The wavelength calibration for the old processing version used a limited set of dispersion coefficients (ADC_CORR, only few carrousel positions). Our new processing makes use of the latest dispersion coefficients determined for all carrousel positions

(GWC_CORR). The relative difference between the old and new wavelength scale forms an S-shaped curve (Fig.2). Typical differences in such cases are smaller than 0.2 Å.

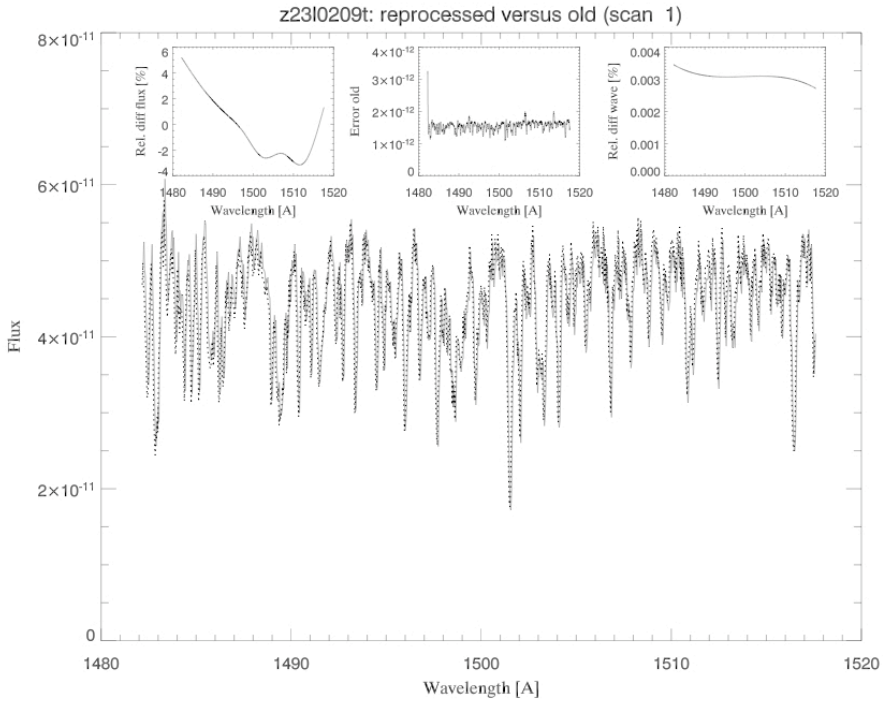

Figure 2: Calibration differences between the old (dotted line) and new processing (solid line). The inset plots show from left to right the relative flux difference $(F_{new}-F_{old})/F_{new}$, the old errors, and the relative wavelength difference $(\lambda_{new}-\lambda_{old})/\lambda_{new}$.

2.2 Erroneous datasets

In the end, 33 datasets did not get processed (28 science and 5 non-science). The names for these datasets are listed in Table 2. In all cases problems occurred either during the observation (e.g. re-centering, loss of lock) or the telemetry (e.g. missing groups or engineering data). It was decided that it would be too much work to follow up on the remaining 33 datasets and the GHRS reprocessing effort was declared to be finished.

3. Summary

The entire GHRS database contains 24272 datasets; 10555 of these are science data. All of them were reprocessed with the best available reference files. At the end only 33 datasets did not run through the pipeline and Table 2 contains a listing of those datasets. This final calibration replaces the old version and is available at all three datacenters, MAST, CADC and ST-ECF.

Table2: List of problematic GHRS datasets that could not be calibrated.

Dataset name	**Dataset name**	**Dataset name**
z0wk010lm	z2qx0307t	z3490304t
z0wx030bm	z2tq0106t	z34c010at
z0zi010xt	z2v4010lt	z364010gt
z16z0106m	z2y50504t	z364040qt
z23b0112t	z2zx0207t	z37u1006t
z2c20507t	z301010pt	z37u1308p
z2co0407t	z301010tt	z3f3b204t
z2co040at	z301011lp	z3g0510sm
z2dq1604t	z31n010tt	z3gb0106p
z2mk0606t	z31u010it	z3gz040lt
z2mp0106t	z32o0508t	z3i10302t

4. Acknowledgement

We would like to thank Charles Proffitt, a former GHRS team member, for his tremendous help in this recalibration work and for numerous helpful discussions of the instrument specifics. Special thanks also to Paul Barrett for tracking the software bug down and providing a fix for it.

Appendix

The list below contains the exclusion criteria used for the selection of science observations.

target_exclusion NULL
target_exclusion BIAS
target_exclusion BORESIGHT
target_exclusion DARD-PMT
target_exclusion DARK
target_exclusion EARTH*CALIB
target_exclusion FFT*
target_exclusion GLOW-TAR
target_exclusion INTFLAT
target_exclusion KSPOTS
target_exclusion MOON*
target_exclusion NICMOS-POINTED-FLAT
target_exclusion NULL
target_exclusion PMT-DARK-SKY
target_exclusion TALED
target_exclusion UVFLAT
target_exclusion VISFLAT
target_exclusion WAVE
target_exclusions POST-SAA-DARK

groundmode_exclusion IMAGE
groundmode_exclusion TIME-RESOLVED
groundmode_exclusion TARGET*ACQUISITION

grating_exclusion M*
grating_exclusion SAF
grating_exclusion NDF
grating_exclusion NULL

instrument_exclusion NULL
instrument_exclusion FGS
instrument_exclusion HSP

operating_mode_exclusion ACQ*

data_source_exclusion LOGS
data_source_exclusion REGR
data_source_exclusion RING
data_source_exclusion TAPE