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WFC3 Instrument Science Report 2009-09

The WFC3/UVIS Reference Files: 3. Updated Biases and Darks

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May 22, 2009

ABSTRACT

A second generation of bias and dark reference files for the Wide Field Camera 3 (WFC3) UVIS-1′ flight detector were assembled and delivered to the Calibration Database System (CDBS). These reference files were created from ground data in the final thermal vacuum campaign at the Goddard Space Flight Center (GSFC). In this report, we present updates made to the first generation of reference files including modifications to the CCDTAB and BPIXTAB files, calwf3, and header keyword changes.

Introduction

We have assembled the second generation of bias and dark reference files for the WFC3 UVIS-1′ flight detector from the calibration data obtained in the third and final thermal vacuum campaign (TV3) at GSFC. The first generation of reference files are described in ISR 2008-42 (Martel et. al 2009). The scripts used to generate the WFC3/UVIS reference dataset are described in detail in TIR 2008-01 (Martel et al. 2008a).

Input Bias and Dark Files

The CCD Characteristic Table (header keyword CCDTAB and file name *_ccd.fits) and the Bad-Pixel Table (keyword BPIXTAB and the file name *_bpx.fits) were updated with the most current values prior to generating the bias and dark reference files. As a result of reference flat field analysis, the gain values for each amplifier has been updated to 1.56 e-/DN, to remove a small residual offset of $\sim 0.5\%$ between amps C and D. BPIXTAB now includes 4 bad columns on Chip $\#2$ (science image FITS file extension [1]) in addition to the 3 bad columns identified previously on Chip $\#1$ (science image FITS file extension [4]) . The values for the BPIXTAB are shown in Table 1; listed are

Table 1. Bad Columns Flagged in BPIXTAB

CCDCHIP	PIX1	PIX2	LENGTH	VALUE	AXIS
1	2541	1	102	4	2
1	2543	1	102	4	2
1	2869	1	1107	4	2
2	242	1	2051	4	2
2	243	1	2051	4	2
2	2696	1	2051	4	2
2	2707	1	2051	4	2

the chip of the region being flagged, starting pixel coordinates (x,y), the length of the feature, the bad pixel value assigned to the region, and the direction of the region (axis 2 is along the columns). The final delivered CCDTAB and BPIXTAB tables used to reprocess individual bias and dark frames are: t291659mi_ccd.fits and t2c1533si_bpx.fits. Individual bias frames were calibrated with DQICORR and BLEVCORR (overscan); calibration of darks included a bias subtraction (BIASCORR) as well.

The reference file generation process involves combining multiple individually calibrated bias and dark images using the *calwf3* pipeline task "wf3rej" which, includes cosmic ray (CR) identification and rejection. The CR rejection and image combination parameters used in wf3rej are contained in the Cosmic Ray Rejection (CRR) parameters reference table (CRREJTAB). We used a custom CRREJTAB with the "skysub" parameter set to "none". For first generation reference files skysub was set to "mode", but because the background levels in the bias and dark images are approximately zero this gave unreliable results for biases and darks. The remaining parameters were left at their current default values and are listed in the "cosmic ray rejection algorithm parameters" keyword block in the reference file headers, which are based on the ACS values in the reference file n4e12511j_crr.fits.

In order for CDBS to handle bias reference file selection efficiently, an updated set of CDBS expansion rules was implemented (Baggett et al. 2009). This change now expands the keyword CCDAMP and adds the APERTURE keyword to the selection criteria. Second generation reference files now contain the CCDAMP/APERTURE keyword settings that allow CDBS to apply a single calibration file to multiple observing modes. For example, a full frame four-amp bias can be applied to a full-frame four-amp science image taken with any of the WFC3/UVIS allowed aperture settings (UVIS1, UVIS1-FIX, etc.).

Table 2. Final Bias Reference Files from TV3 Ground Campaign.

File	Number of Input Frames	Amplifiers	Binning	Temp. (Celsius)	MEB	Mean (DN) (Chip #1, Chip #2)	Stddev (DN) (Chip #1, Chip #2)	Median (DN) (Chip #1, Chip #2)
t3h2007bi_bia.fits	12	ABCD	1	-49°	1	0.422, 0.278	0.649, 0.636	0.405, 0.254
t3h2007ci_bia.fits	64	ABCD	1	-82°	1	0.063, 0.028	0.244, 0.252	0.055, 0.018
t3h2007di_bia.fits	22	ABCD	1	-49°	2	0.387, 0.223	0.505, 0.492	0.376, 0.205
t3h2007ei_bia.fits	63	ABCD	1	-82°	2	0.078, 0.013	0.245, 0.253	0.070, 0.007
t3h2007fi_bia.fits	15	ABCD	2	-82°	1	0.256, 0.120	0.542, 0.542	0.242, 0.098
t3h2007gi_bia.fits	19	ABCD	2	-82°	2	0.243, 0.156	0.485, 0.484	0.235, 0.136
t3h2007hi_bia.fits	36	ABCD	3	-82°	1	0.607, 0.538	0.399, 0.401	0.592, 0.533
t3h2007ii_bia.fits	38	ABCD	3	-82°	2	0.659, 0.508	0.381, 0.385	0.648, 0.503

Table 3. Final Dark Reference Files from TV3 Ground Campaign.

File	Number of Input Frames (Total Time)	Amplifiers	Binning	Temp. (Celsius)	MEB	Mean (e-/hr) (Chip #1,Chip #2)	Stddev (e-/hr) (Chip #1,Chip #2)	Number of Hot Pixels (Chip #1,Chip #2)
t3420174i_drk.fits	2 (200 sec)	ABCD	1	-49°	1	17.834, 9.396	300.492, 93.672	2554335, 2805090
t3420175i_drk.fits	6 (18000 sec)	ABCD	1	-82°	1	0.221, 0.182	4.982, 1.593	97, 79
t3420176i_drk.fits	3 (1200 sec)	ABCD	1	-49°	2	41.22, 30.665	131.472, 28.598	1501166, 2140637
t3420177i_drk.fits	4 (4000 sec)	ABCD	1	-82°	2	0.310, -0.144	17.363, -5.681	102, 82
t3420178i_drk.fits	2 (2000 sec)	ABCD	2	-82°	1	1.473, 1.113	28.321, 8.896	145, 106
t3420179i_drk.fits	2 (2000 sec)	ABCD	2	-82°	2	3.769, 2.446	31.946, 8.914	138, 151

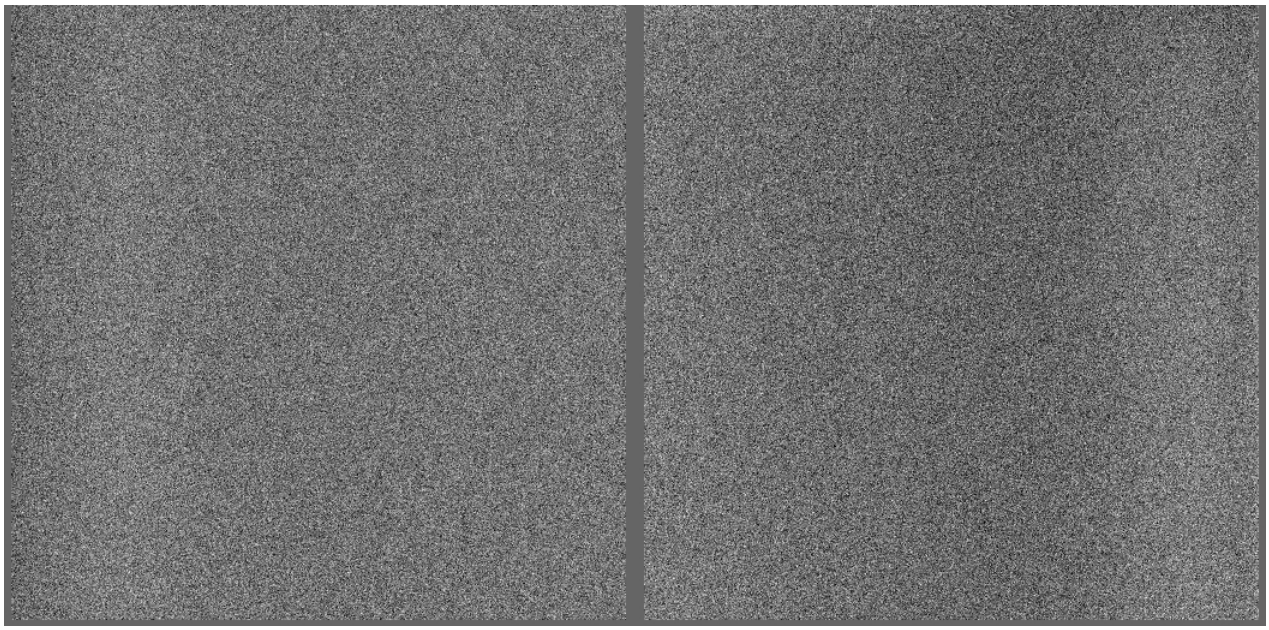

Figure 1. *Chip #1 (science image FITS file extension [4]) of bias reference file t3h2007ei_bia.fits.*

Reference Files

Tables 2 and 3 list the properties of the second generation bias and dark reference files delivered to CDBS: the file name, the number of input frames, amplifiers, binning, temperature, MEB side, the statistical mean, standard deviation and median for both CCD chips. Note that on-orbit data will be taken at -82°C and on MEB2.

Figure 1 shows Chip #1 (science image FITS file extension [4]) of the bias file t3h2007ei_bia.fits, a full-frame four-amp image taken on MEB2 and at -82°C. As can be seen in this image, there are slightly brighter regions running down the image on both the left and right hand sides of the chip. Present in all full-frame UVIS images, these features are stable and the bias file subtraction step provides an effective correction. These pixel values are $\sim$0.1 (DN) higher than the mean pixel value. The final bias reference file includes the overscan regions, has an integration time of 0 sec, and is in units of DN.

Figure 2 shows Chip #1 (science image FITS file extension [4]) of the dark file t3430177i_drk.fits, a full-frame four-amp image taken on MEB2 and at -82°C. The final dark reference file has trimmed overscans, an exposure time of 1 sec, and is in units of e-/sec.

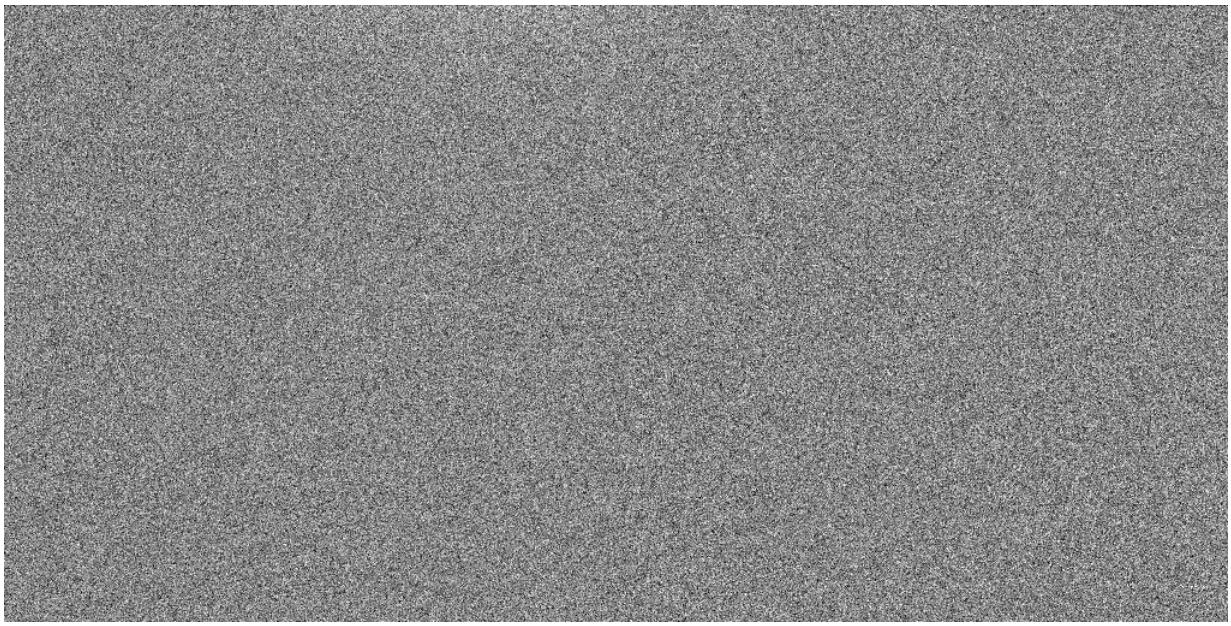

Figure 2. *Chip #1 (science image FITS file extension [4]) of dark reference file t34301771_drk.fits.*

Calwf3 Updates

The first generation reference files were created from images calibrated with *calwf3* version 1.1, while the second generation reference files were processed with *calwf3* version 1.2a. Several changes made to the wf3rej module of *calwf3* v1.2a affect the generation of the reference files.

First, the previous version of wf3rej mistakenly assigned CR flags to pixels in the CR-combined image when one or more input values for the pixel were identified as containing a CR, even though there were remaining unrejected values from which to compute a clean output. Such pixels were needlessly being treated as bad in the output combined image. The new version of wf3rej only marks an output pixel as bad if all inputs for that pixel are rejected.

Second, when pixels in an input image are identified as containing a CR hit, a search of neighboring pixels is performed to see if they also meet the rejection criteria. In the previous version of wf3rej, this "growth" of rejected pixels was not being handled properly, such that some neighboring pixels were not rejected even when they satisfied the rejection criteria. The new version now handles this process correctly, which can result in a larger region of neighbors being rejected around a CR hit, thus resulting in a more thorough removal of the effect of the CR in the output combined image. Finally, the pixel rejection portion of the overscan correction algorithm (BLEVCORR) was improved, resulting in more accurate determinations of the overscans without contamination by outlier or saturated pixels.

On-Orbit

Cycle 17 CCD Daily Monitor Program (proposal 11905, PI Borders et al.) will acquire daily dark (900 sec) and bias (0 sec) frames. All frames are in standard readout mode (four-amp ABCD, gain = 1.5 e-/DN, 1x1 binning). Clean frames will be produced with *calwf3* and combined into superbiases and superdarks for delivery to the CDBS as described in WFC3 TIR 2008-01 (Martel et al.) Bias frames for the subarray UVIS1-2K2-SUB (using the default amp B readout) are also obtained by the CCD Daily Monitor Program.

Due to the extremely low dark current exhibited by normal pixels (< 0.5 e-/hour), large numbers of dark frames are required to produce a statistically significant per-pixel measure. For this reason dark reference files for on-orbit data will initially have their normal pixels set to zero preventing the dark calibration from inserting extra noise into the science data. The warm and hot pixels will of course be retained in the dark reference file, allowing the *calwf3* DARKCORR step to calibrate these off-nominal pixels. The hot pixels are defined above some lower threshold. For ground data, we chose 60 e-/hour in the standard readout mode (four-amp ABCD, gain = 1.5 e-/DN, 1x1 binning). This value is based on the tail of the histograms from a first pass of the superdarks. The same threshold was used for all binnings. As on-orbit darks become available and are analyzed, these thresholds will be adjusted accordingly.

The bias and dark reference files delivered to CDBS will be used to correct all on-orbit WFC3 UVIS science frames. The main characteristics of the CCD, such as readnoise and warm/hot pixels will be measured and monitored over periods of days, weeks, and months. The rate at which reference files are delivered to CDBS will be determined once statistics are built from the daily dark and bias frames.

Conclusions

We have created the second-generation bias and dark reference files for the WFC3/UVIS flight detector from ground data acquired in the final thermal vacuum campaign at GSFC using updated CCD characteristics, cosmic-ray rejection parameters, and processing pipeline *calwf3*. These files replace the first generation files and will serve to calibrate the early, on-orbit SMOV4 science images.

References

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