5.1.10 ANTI-BLOOMING PIXEL PAIRS

5.1.10.1 NAC FM ANTI-BLOOMING PIXEL PAIRS CALIBRATION RESULTS

As reported in Reference 5.1.10.1-1

Reference 5.1.10.1-1 - IOM 388-PAG-CCA98-10, "NAC FM Calibration Results: Anti-blooming Pixel Pairs", Bob West and Charlie Avis, April 16, 1998

Reference 5.1.10.1-2 - IOM 388-PAG-CCA98-2, "NAC FM Calibration Results: Sensor Blemishes", C. Avis , January 20, 1998

5.1.10.1.1 INTRODUCTION

Long exposures with anti-blooming ON will show bright/dark pairs of pixels scattered throughout the image. According to J. Janesic (private communication) these are caused by traps which preferentially accumulate electrons at the expense of the adjacent pixel under the action of the anti-blooming voltage forcing function. The bright pixel is one line higher than the dark pixel. The magnitude of the effect will depend on the size of the trap(s), a time constant for trap filling, and the exposure level.

Narrow-angle Flight Model thermal/vacuum Light Transfer images were used for characterization of this pixel pairing. These data were taken at Gain 2 in the 1x1 mode at chamber temperatures of -10° C and +5° C. The CCD was maintained at about -90° C. Exposures were available up to 460 seconds with anti-blooming ON.

We are unable to formulate an accurate model for this process, but heuristically it should obey the following approximate form:

$$\frac{DN(line+1,sample) - DN(line,sample)}{DN(line+1,sample) + DN(line,sample)} = a\left(1 - e^{-bt}\right)$$ **Equation 5.1.10.1-1**

where t is the exposure time
a and b are positive constants to be determined by fitting images taken at different times

5.1.10.1.2 METHOD

The expectation is that at short exposure times the difference/sum should be approximately linear with time, and at long exposure times it should approach an asymptotic value. The calibration analysis consisted of two steps:

1. find the pixels which show bright/dark pair behavior from the longest flat-field frames with anti-blooming ON, and
2. attempt to fit the difference/sum measured on images at a variety of exposure times to the formula above.

5.1.10.1.3 RESULTS

We found that some pixels do not follow the above equation. Some display erratic behavior as a function of exposure time. Therefore we do not attempt to apply an algorithm which performs the inverse of the above equation. We recommend rather that the calibration of these pairs be done simply by taking their mean value. A more sophisticated algorithm can be imagined whereby the brightness values are calculated by interpolating nearby values from unaffected pixels. That idea is left for future implementation. The product of this calibration procedure is a map (a digital image) of the pixel pairs.

Bias and dark current values were subtracted from the longest exposure (460s) image. The resulting image was examined for all pixel pairs having difference/sum greater than 3σ relative to the noise (1σ $\sqrt{\text{electrons}}$ in the raw image). The smallest value of difference/sum in this limit is 0.08 while the largest detected was 0.9. An image file was produced having values of 0 at each pixel location except at the bright pixel locations of pairs identified according to the above criterion. The non-zero values in the image give the difference/sum times 10000. 15490 non-zero values (pixel pairs) were identified.

In order to see if the difference/sum values behave according to expectation (Equation 5.1.10.1-1) the difference/sum was plotted as a function of time for 10 images with exposure times ranging from 22 s to 460 s. A sub-region of these images is shown in Figure 5.1.10.1-1. The sub-region is 10 pixels square centered near (sample,line) (933,560). An arrow coming from the right points to the bright/dark pair at (933,560) in the bottom right panel of Figure 5.1.10.1-1. Several other bright/dark pairs can be seen in this panel. A second arrow coming from the bottom points to one of these (930,559). Plots of difference/sum are shown in Figure 5.1.10.1-2 and Figure 5.1.10.1-3 for these pairs.

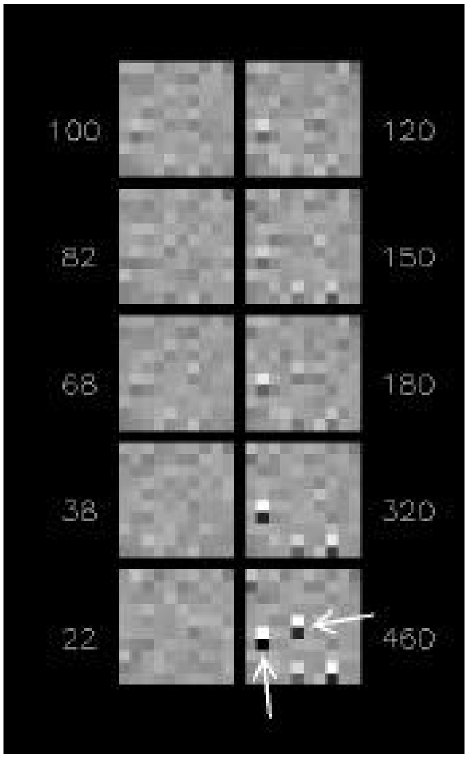

Figure 5.1.10.1-1- 10X10 pixel subregions centered near (933,560). Exposure times (seconds) are indicated to the left or right of each panel.

The pixel pair at (930,559) behaves as predicted by Equation (1). A least-square fit was made to these points, and the resulting smooth curve is shown in Figure 5.1.10.1-3. The root mean square deviations from the fitted curve are 0.007 and the maximum deviation is 0.015. These deviations are consistent with a good fit at the noise level of the data. By contrast the data for (933,560) shown in Figure 5.1.10.1-2 do not fit the curve. Most striking is the fact that the point with the second-longest exposure time shows virtually no bright/dark difference and some differences are of the wrong sign. We offer no explanation of this behavior.

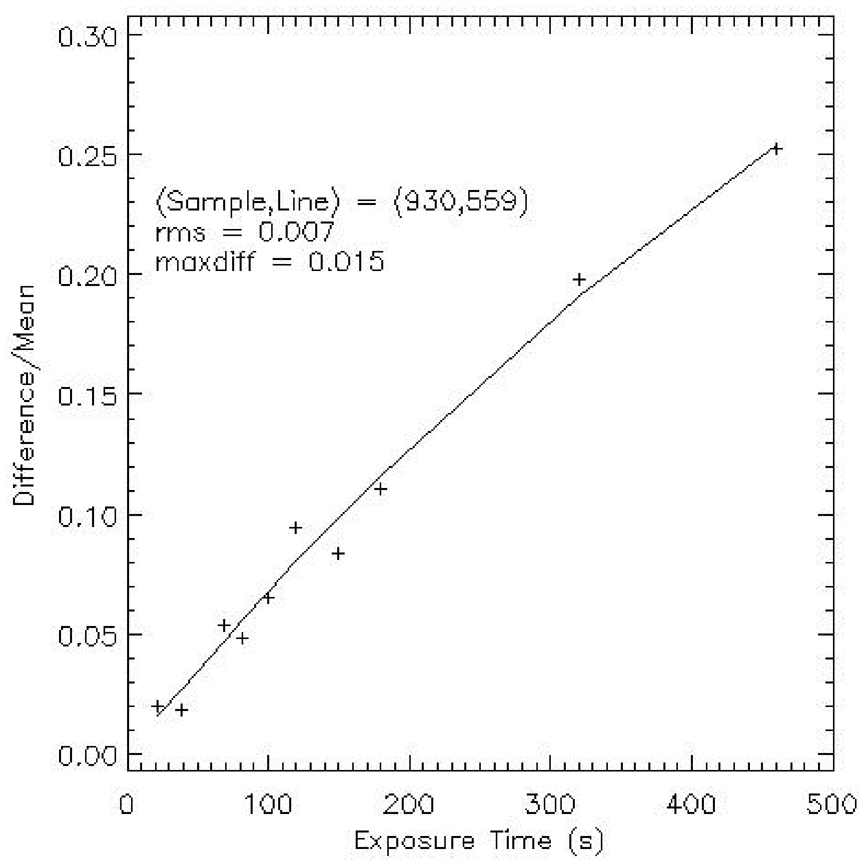

Figure 5.1.10.1-2 - Difference/sum for location (930,559)

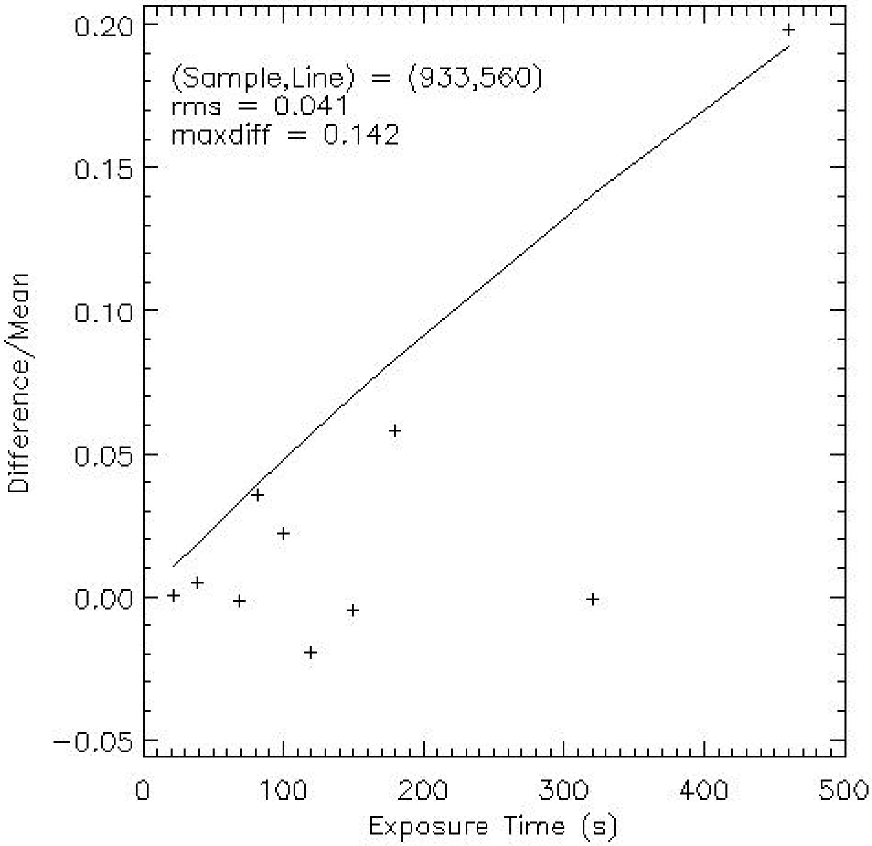

Figure 5.1.10.1-3 - Difference/sum for location (933,560)

5.1.10.1.4 CONCLUSIONS

1. Bright/dark pixel pairs at the 3σ (0.08 in difference/sum) or higher level have been identified. An image file named ABPAIR_MASK.NA with non-zero values at the pixel locations of the bright component of the pair can be used to mask these pixels during the calibration of in-flight images. The values in ABPAIR_MASK.NA are 100,000 times the DN ratio expressed in Equation(1) divided by the exposure time.

2. The difference/sum values for some pixels follow a pattern which is consistent with a heuristic idea for how they should behave. Other pairs display considerable and unpredictable scatter.

3. A crude approach to deal with these pairs would be to replace their values with the mean for the two. A better approach would be to use adjacent and surrounding good pixels to interpolate for the locations of the bright/dark pairs. This latter method would better conform with intensity gradients in the image. In addition, this method would be easily implemented by adding these pixels to the Blemish File discussed in Reference 5.1.10.1-2.

5.1.10.1.5 IMAGES USED FOR ANALYSIS

image	day	time	observation	gain	mode	expos	temp

120070	139	5:55:7.0	LIGHT_TRANSFER_235	2 (100K)	FULL	320000	-9.
120071	139	6:4:32.0	LIGHT_TRANSFER_235	2 (100K)	FULL	460000	-9.
120072	139	6:7:8.0	LIGHT_TRANSFER_236	2 (100K)	FULL	82000	-9.
120142	139	9:47:57.0	LIGHT_TRANSFER_243	2 (100K)	FULL	150000	-9.
120198	139	14:3:40.0	LIGHT_TRANSFER_247	2 (100K)	FULL	120000	-9.
120201	139	14:16:41.0	LIGHT_TRANSFER_247	2 (100K)	FULL	180000	-9.
120221	139	15:53:26.0	LIGHT_TRANSFER_246	2 (100K)	FULL	22000	-9.
121141	142	8:23:35.0	LIGHT_TRANSFER_332	2 (100K)	FULL	38000	6.
121144	142	8:31:50.0	LIGHT_TRANSFER_332	2 (100K)	FULL	68000	6.
121147	142	8:41:39.0	LIGHT_TRANSFER_332	2 (100K)	FULL	100000	6.