NICMOS Bias Dependent Calibration

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ABSTRACT

We present our latest calibration work of the NICMOS instrument on the Hubble Space Telescope. This new calibration method uses a novel method to determine the Q.E. of the detector, expressed as an effective temperature called biastemp, directly from the science exposure. This has allowed, as we show here, to better monitor the behavior of the instrument's three detectors, providing calibration files that account for changes in photometry, flat-fields, and different components of the dark signal, including the shading and the amplifier glow. It has also allowed us improve the calibration of this instrument by providing bias level specific calibration files such as flat-fields, darks, and shading. We express this as an idealized temperature (biastemp) of the instrument which is determined from the bias level of the data, and which is determined using the first read of these non-destructive read, multi-accum datasets. It has allowed us to determine this biastemp value of each of the three NICMOS detectors to within 0.05K and offers a significant improvement over the available mounting cup temperature sensor that has been used in the past, as it is as precise but is a direct measurement of the state of the detector, whether truly due to a change in temperature or internal voltage supply.

GOAL

The NICMOS detectors on HST are extremely sensitive to changes in operating temperature and supply voltage. These temperature and voltage variations affect quantum efficiency, dark current and bias in ways that limit overall sensitivity and make calibration difficult. We assume here that the voltage supplied to the detectors is constant, which is not known, and express observation as an idealized temperature (biastemp) that assume no other changes but that of temperature.

TEMPERATURE AND BIAS LEVELS

Each detector quadrant has its own seperate bias versus mounting cup temperature relationship, with similar slopes but different zeropoints. This gives 4 independent measures of temperature from bias per readout, each with its own noise characteristic. The RMS for these measurements are +/- 0.3, 0.7, 0.5, and 0.1K for the four quadrants, respectively (Figure 1).

VOLTAGE AND BIAS LEVELS

The bias level of each quadrant is affected by fluctuation in the voltage level of the instrument from the NICMOS LVPS, a constant-current power supply. If the voltage supplied by the spacecraft power bus changes, the swithing LVPS in NICMOS compensates for it. When the spacecraft enters orbits, the batteries begin to drain and the bus voltage drops. The LVPS compensates by changing the width of the switching pulse but this results in slightly different bias level in a given NICMOS exposure. During the process of data-reduction, the zeroth/bias read of a NICMOS non-destrutive series of reads is subtracted so that this effect does not affect the science content of the exposure. But this variation in bias level imposed by the LVPS complicates using the bias level as a proxy for temperature measurement. The LVPS states are however quantized into 7 states in each quandrant. One way to solve this problem is to compare two quandrant which are in phase together. Plotting the mean bias level of each quadrant against the other three reveals a series of ellipses showing the 7 quantized "states" (Figure 2).

Subracting off the sinusoidal LVPS signal corrects all the states to a commmon bias. Residuals are temperature induced. After correcting for possible voltage-induced phase, the bias dependence is only temperature dependent. The typical accuracy reached after applying this correction is 0.05K (Figure 3). While we talk here of a real temperature, this assume no other changes in LVPS voltages, which might not be appropriate and would result in a change in detector Q.E. that would mimic a physical temperatur echange.

IMPLEMENTATION

The NICMOS temperature from bias method had been implemented in Python is distributed as part of the STSDAS/NICMOS Pyraf package. The task is called CalTempFromBias and can be ran by the user. It is now part of the routine NICMOS pipeline calibration and is used to select the best data calibration files.

COMPARISON WITH MOUNTING CUP TEMPERATURE

Comparing the temp-from-bias derived temepature versus the temperature measured by mounting-cup sensor shows that while the mounting cup temperature has been kept constant, the biastemp of the detector has been going down (Figure 4). We assume that this change of biastemp is the reason for any observed variation of the Q.E. of the detector. In the past, darks and flat-fields were generated for specific observing dates. This is appropriate for a slowly varying system. The temp from bias method allows us to now match biastemp specific flat-fields and darks to the measured biastemp of given exposures.

EFFECT ON NICMOS FLATFIELDS

The following few figures compares the use of temporal, or epoch, flatfield and of biastemp flatfields. The biastemp flatfields result in a significant improvement in the ability of the flatfields to correct for Q.E. variation across the detector. The figure on the left shows the ratio images obtained by dividing each SCI extension in NIC3, F110W temperature dependent flat by the SCI extension in the static flat file, for pre and post-NCS data respectively. The biastemp goes up as we go from panel 1 to panel 5. Panel 3 in figure 6a and panel 4 in figure 6b are relatively flat due to the fact that the temperature range of SCI[11] image is close to the biastemp of the static flat file. From both the figures we can conclude that the biastemp flat-fields do have some structure as compared to the static flat-field and the structure of flat field does depend upon temperature.

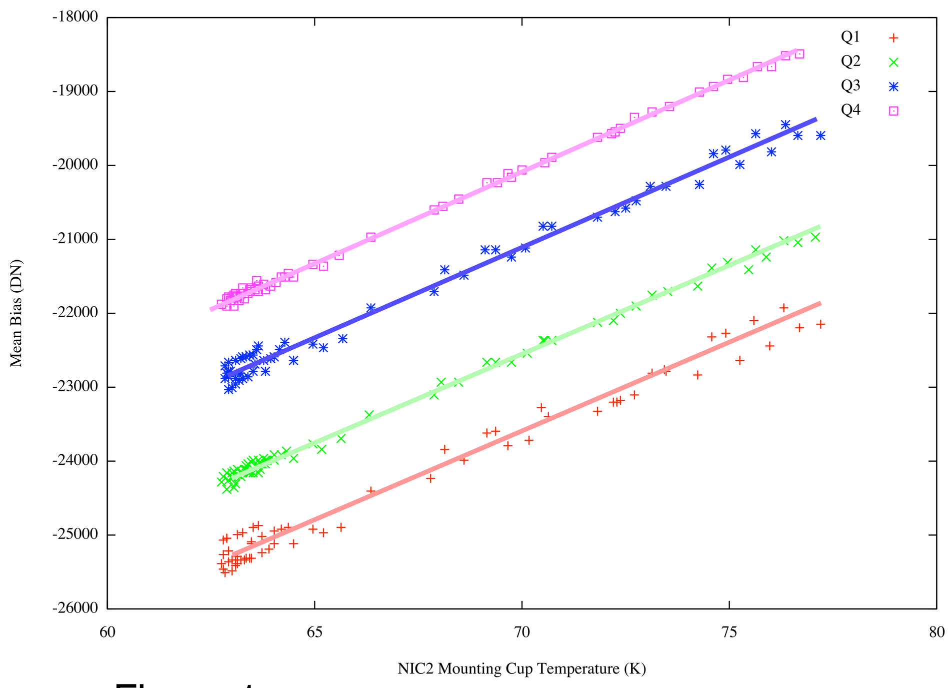


Figure 1

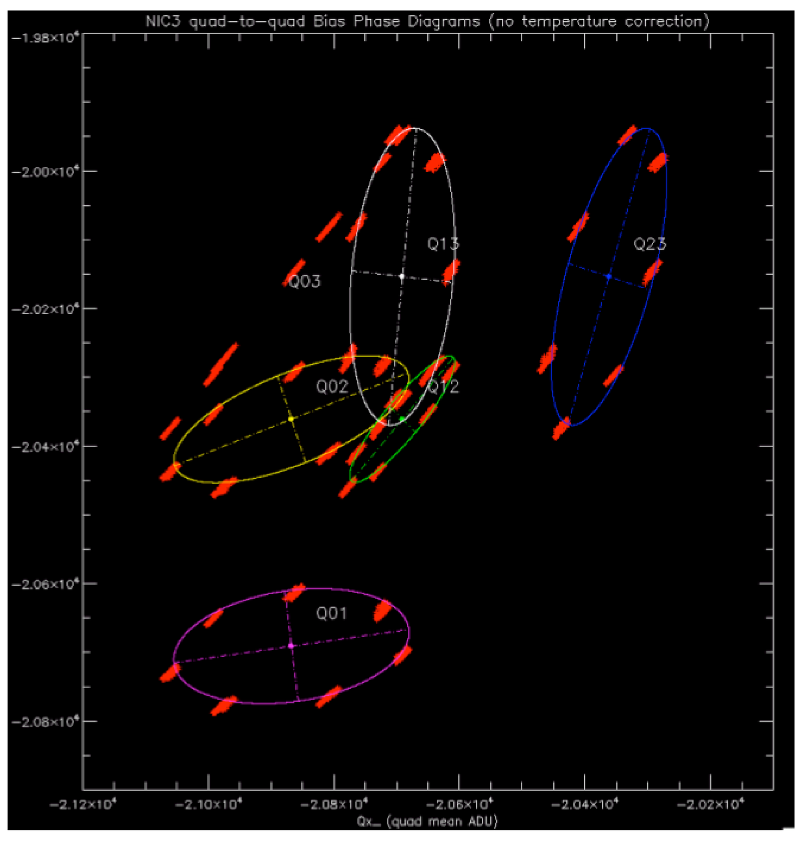


Figure 2

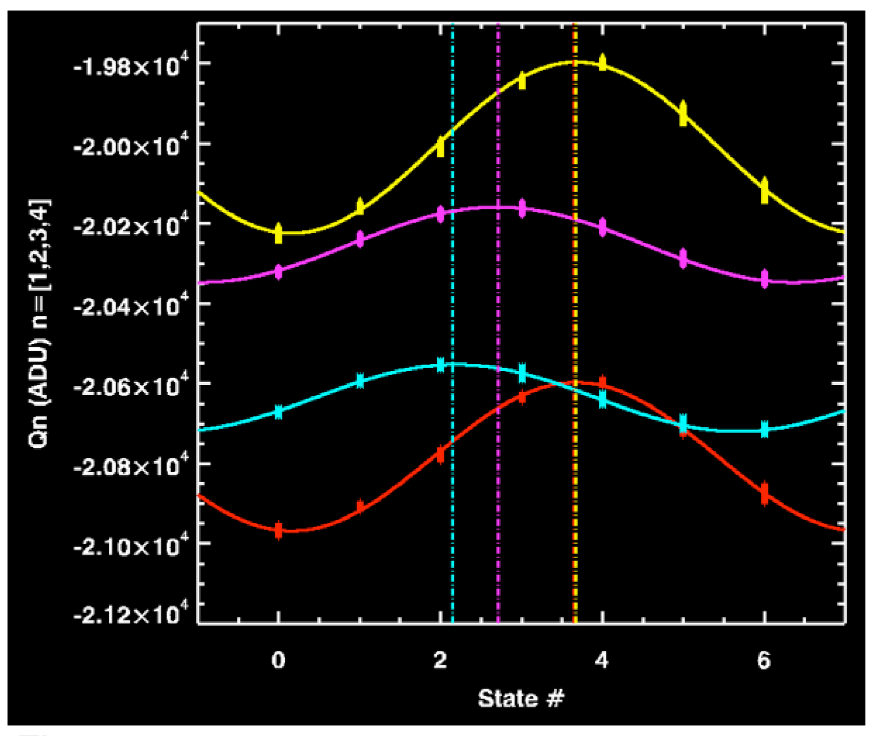


Figure 3

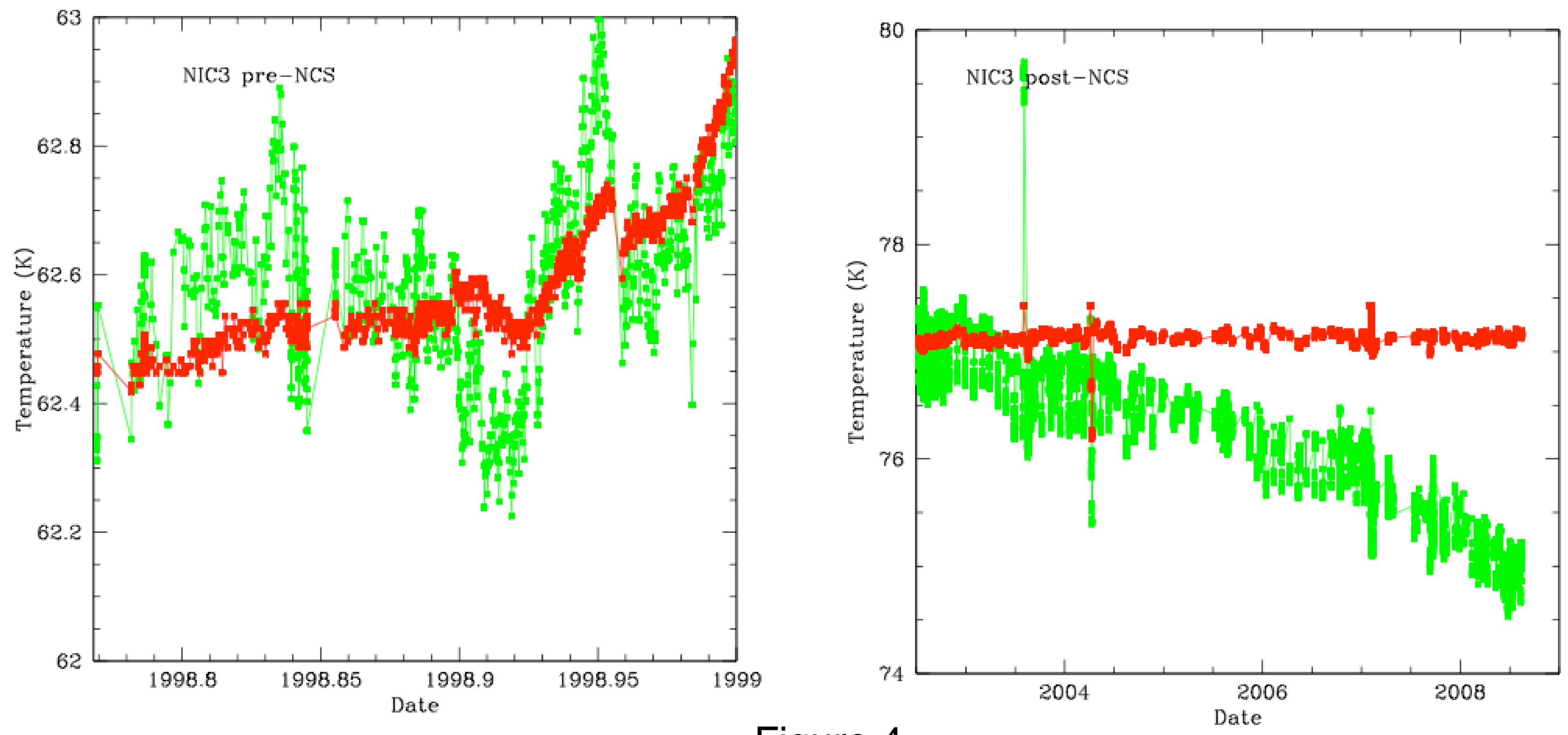
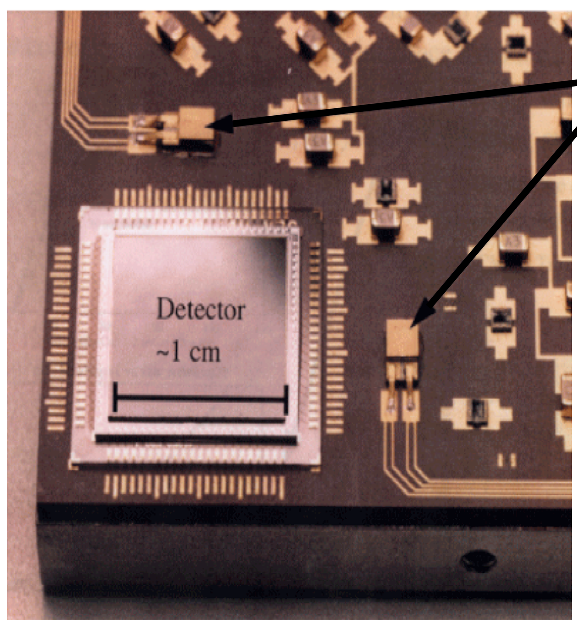


Figure 4

What is NICMOS?

NICMOS is a cooled, internally corrected, near-IR imaging camera which takes advantage of HST's stable optics and dark on-orbit backgrounds to produce filtered imaging with high sensitivity and Strehl ratio, low resolution (R~200) multi-object grism spectroscopy, coronagraphy, and polarimetry. The three independent NICMOS cameras offer fields of view ranging from small to medium, and angular resolutions from high to moderate.

Installed on HST	Feb. 1997 (SM2)
Function	NIR imaging, low-res slitless spectroscopy, coronagraphy, polarimetry
__ range	0.8-2.4 _m
Optical Elements	Filters, grism(s), polarizers
Detectors	256x256 HgCdTe (3)
Field(s) of View	11,19,51 arcsec square (cameras 1,2,3 resp.)
Scale (arcsec/pixel)	0.043,0.075,0.20 arcsec, resp.
Enhancement factor over predecessor instrument (if any)	No predecessor: 1st IR on HST
Cost	$136M (FY00$)
Current status/health	Operational, improved since launch



FPA temperature sensors. These are not used dur to thermal emission, high noise, and random bias level after power cycling.

The nearby "mounting-cup" sensors are on an aluminum bracket that this board is connected to.

Figure 5 shows the measured Q.E. response as a function of biastemp, normalized at T=63K. Curves are shown for wave-lengths 1.1, 1.6 and 2.2 micron. Shorter wave-lengths have steeper slopes.

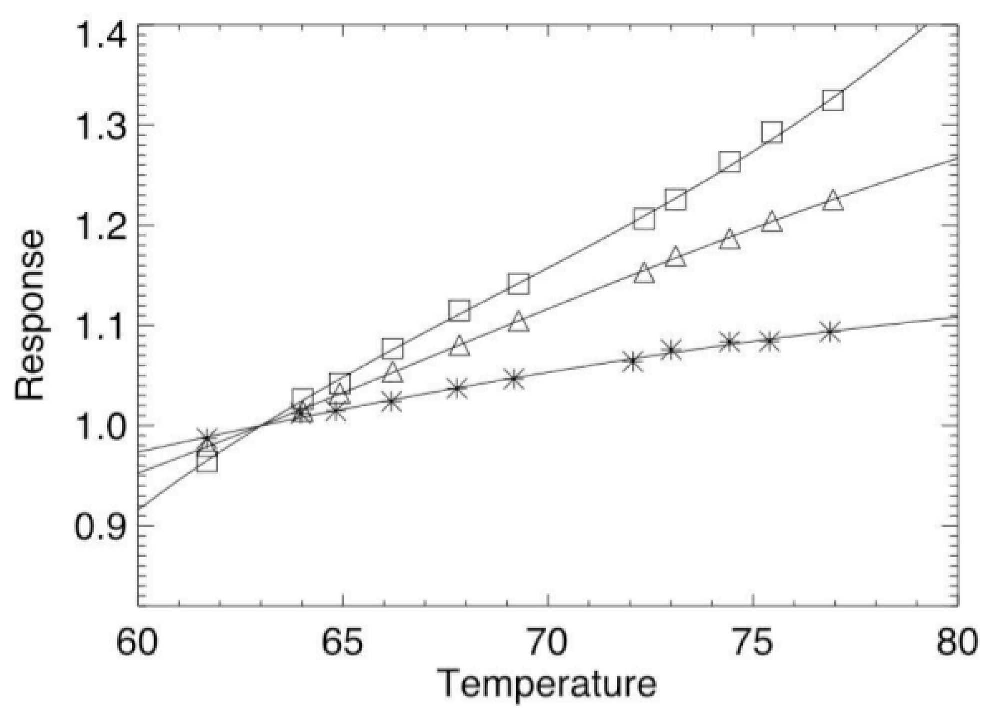


Figure 5

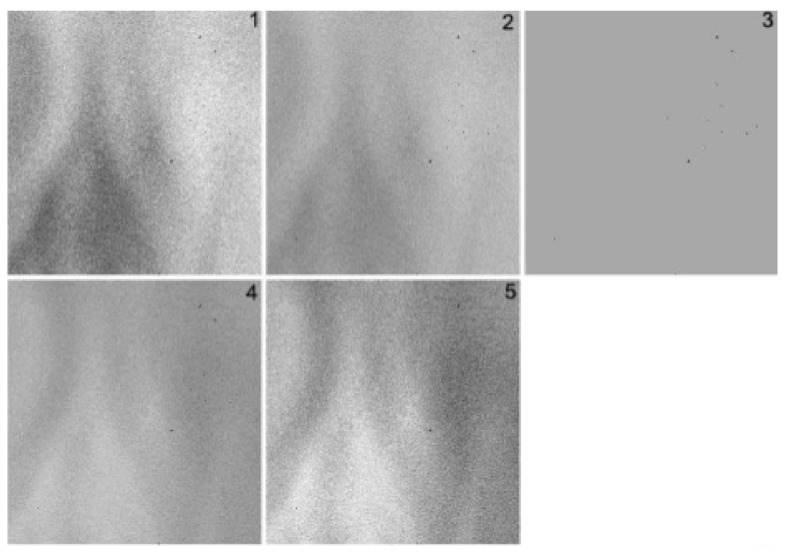


Figure 6a

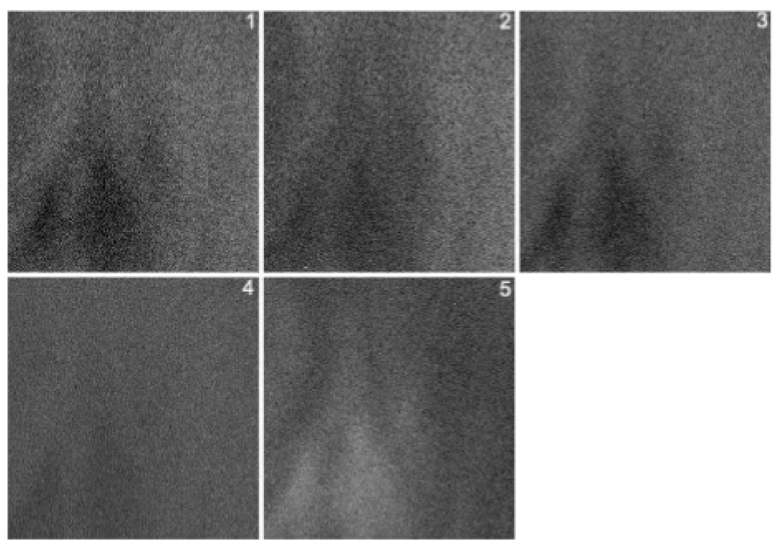


Figure 6b

CONCLUSION

Data obtained using NICMOS have been known to require careful choice of flatfield and dark current images in order to properly calibrate observations. This has traditionally be done using "epoch" data calibration products as the mounting cup sensor showed no sign of any temperature variation in the instrument.

The novel approach of determining the state of the dectector using the bias level of the detector itself as data is taken has however shown that the Q.E. of NICMOS detectors has varied significantly over the last few years, mimicking the effect of a gradual lowering of detector temperature. While we cannot rule out that this effect is not solely temperature driven but migth also be voltage driven, the effect is similar and we are now able to directly measure the state of the NICMOS detectors for any given datasets with a biastemp accuracy of 0.05K. This has allowed us to compute biastemp dependend calibration products that are improving the NICMOS data calibration significantly as NICMOS calibration products can be better matched to NICMOS observations.

RELATED INFORMATION AND FURTHER READING

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- Dahlen, T., Barker, E., Bergeron, E., Smith, D. ISR NICMOS 2009-002, STScI, *Temperature Dependent Dark Reference Files: Linear Dark and Amplifier Glow Components*
- Thatte, D., Dahlen, T., ISR NICMOS 2009-005, STScI, *NICMOS Temperature Dependent Flat-fields*
- Dahlen, T., McLaughlin, H., & de Jong, R. 2007, NICMOS ISR-2007-002, STScI, *NICMOS Time Dependent Flat-fields*
- Thatte, D. and Dahlen, T. et al. 2009, "NICMOS Data Handbook", version 8.0, (Baltimore, STScI)