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# Updates to Calnica: Using Temperature Dependent Reference Files

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## ABSTRACT

*This report describes how the `calnica` data reduction software implements temperature dependent reference files in order to correct for temperature dependent variations in the dark current, the flat-fields, and the flux calibration. We describe in detail the logic used by the software to decide when to apply a temperature dependent correction and which temperature to use in that case.*

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## Introduction

`Calnica` is the software that performs instrumental calibration of raw NICMOS data. The `calnica` task is used by the On-The-Fly-Reprocessing (OTFR) and is also available as a task within the NICMOS package of STSDAS so that users can calibrate data after customizing the task. One important aspect of the OTFR is that the latest available calibration reference files are always used. Since reference files are sometimes updated, it may be necessary for users to retrieve data again from the archive using the OTFR, or alternatively run `calnica` using the updated reference files, in order to get the best possible calibration of the NICMOS data. Recently, the NICMOS team has developed a new set of reference files that depends on the detector temperature. In this report we describe how these temperature dependent reference files are implemented in `calnica` and the logic used by the task to decide when a temperature dependent correction should be applied and which temperature to use. We also describe the new image header keywords that are associated with the temperature dependent corrections.

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Detailed descriptions of the reference files and how they were created will be given in separate ISRs (Bergeron 2009, NICMOS ISR, in preparation; Dahlen et al. 2009, NICMOS ISR 2009-002; de Jong 2009, NICMOS ISR, in preparation), see the NICMOS webpage for updates.

## **NICMOS temperature variations**

Measuring the temperature of the NICMOS detectors using the detector bias levels, the so called temp-from-bias (Bergeron 2009, NICMOS ISR, in preparation), shows that there has been a slight drift in temperature during both the first period of NICMOS operations in 1997-1998 and in the era after installing the NICMOS Cooling System (NCS) in 2002. During the pre-NCS era, the temperature increased by  $\sim 1.5\text{K}$  (before the start of the warm-up that ended the pre-NCS era when the detectors were warmed up as the coolant was exhausted), while during the post-NCS era, the temperature has decrease by  $\sim 2.5\text{K}$ . The change in the bias-derived temperature with time is shown in Figure1 for a number of dark exposures in NIC1. Besides the bias-derived temperature (TFBTEMP), the figure also shows the temperature given by one of the mounting cup sensors (NDWTMP11). While the two temperatures show the same behavior (although with scatter) in the pre-NCS era, this is not the case for the post-NCS era.

Starting on September 2, 2008, all NICMOS images taken with MULTIACCUM sampling sequences that are retrieved from the archive have the bias-derived temperature calculated and put into the TFBTEMP header keyword. The IRAF task that performs the calculation, `CalTempFromBias`, is also available as a standalone task in the NICMOS package of STSDAS and can be run on any MULTIACCUM NICMOS data to calculate the bias-derived temperature. Further details on the bias-derived temperature are given in Pirzkal et al. 2009, NICMOS ISR 2009-007 and Bergeron 2009, NICMOS ISR, in preparation. See the NICMOS webpage for updates.

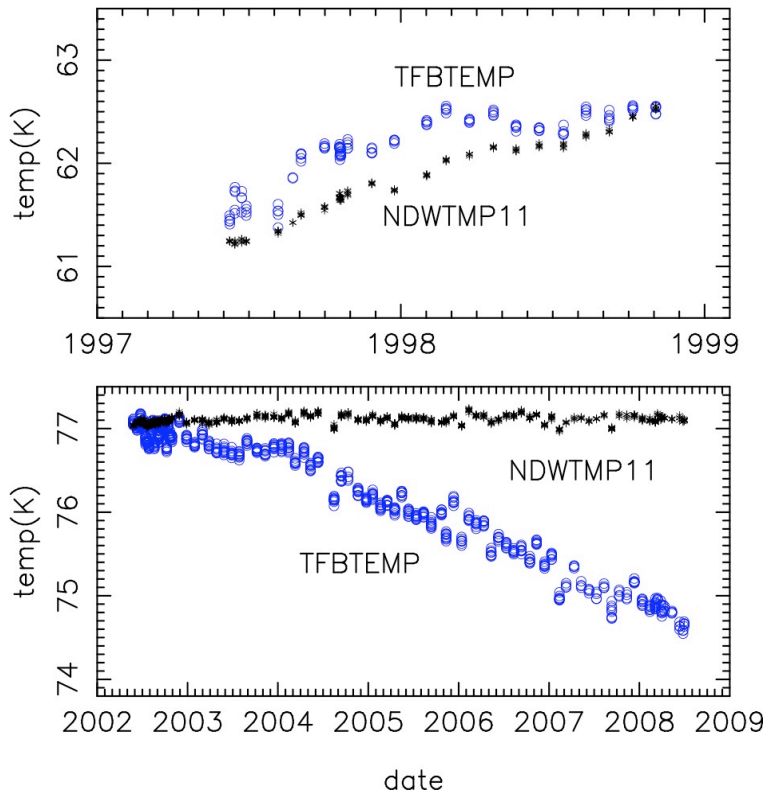


Figure 1. **The bias-derived temperature (TFBTEMP) and the mounting cup temperature (NDWTMP) variation with time for the pre-NCS era (top) and the post-NCS era (bottom).**

### Temperature dependent reference files

We now know that the temperature of the NICMOS detectors varied with time in both the pre-NCS and post-NCS eras. Since we expect that detector characteristics vary with temperature, a proper treatment of this temperature dependence is necessary to make the best possible calibration of NICMOS data. In particular, we expect the dark current to depend on temperature and we know from the monitoring of the NICMOS photometry that the detector quantum efficiency (DQE) depend on temperature (de Jong 2009, NICMOS ISR, in preparation), it is therefore important that reference files and calibration routines in `calnica` takes this into account, in particular when the impact is estimated to be significant.

The creation of the temperature dependent dark reference files, flat-field reference files and photometry tables are described in detail in separate NICMOS ISRs (see information on the NICMOS web page). In this report, we describe how these reference files are implemented in `calnica` and the logic used to decide when a temperature dependent correction should be applied.

## Temperature dependent calibration in `calnica`

There are three stages in `calnica` that include temperature dependence: dark current subtraction, flat-fielding, and photometric calibration. Below we describe each of these steps in some detail.

### *Step 1 – Dark current subtraction*

The primary header of the `*_raw.fits` files contains information on which calibration steps should be conducted when the `calnica` task is run. For the dark calibration step to be conducted, the `DARKCORR` step should be set to `PERFORM`, which is the default setting for all normal science images. The header also contains keyword information on two different types of dark reference files that can be used in the `DARKCORR` step of `calnica`. The `DARKFILE` keyword contains a static non-temperature dependent dark reference file with extension `*_drk.fits`. Each NICMOS sampling-sequence has its own `DARKFILE` and when NICMOS data is retrieved from the archive, this keyword is populated with the reference files that is appropriate for the combination of sampling sequence (given in keyword `SAMP_SEQ`) and the number of reads used in that particular sampling sequence (`NSAMP` keyword). Note that most `*_drk.fits` darks were made in 1997 and are based on synthetic models. The `TEMPFILE` keyword points to the temperature dependent dark reference file (extension `*_tdd.fits`). There is one pre-NCS and one post-NCS `TEMPFILE` for each camera. By default, `calnica` uses the file given by the `TEMPFILE` keyword for the dark current subtraction. Only in the case where the `TEMPFILE` keyword is missing or has a “N/A” value, will the `DARKFILE` be used. All files retrieved from the archive after April 9, 2002 have the `TEMPFILE` keyword populated. However, an actual temperature dependence was initially only implemented for data taken in the pre-NCS era. The post-NCS `TEMPFILE`s were first created to always give a unity scaling, equivalent to no dependence on temperature. The temperature dependence of the post-NCS `*_tdd.fits` files was derived and implemented in 2009. For old data lacking the `TEMPFILE` keyword, we recommend retrieving the data again from the OTFR to get the latest reference files populated in the header keywords, as well as fully calibrated files using the most up-to-date version of `calnica`.

The `TEMPFILE` contains information on the three separate components of the NICMOS dark current: the linear dark, the amplifier glow, and the shading component. Separate NICMOS ISRs describe how these components were constructed (see NICMOS webpage). Below we describe how `calnica` uses these separate components in the temperature dependent calibrations.

### Linear dark

The linear dark current component is found in the first extension (EXT=1) of the \*\_tdd.fits file, i.e., the file given by the TEMPFILE keyword. The linear dark component is normalized to 1 second. Figure 2 shows the linear dark extension for NIC3. Note that there are both pixel-to-pixel variations, creating the “salty” pattern, as well as large-scale gradients.

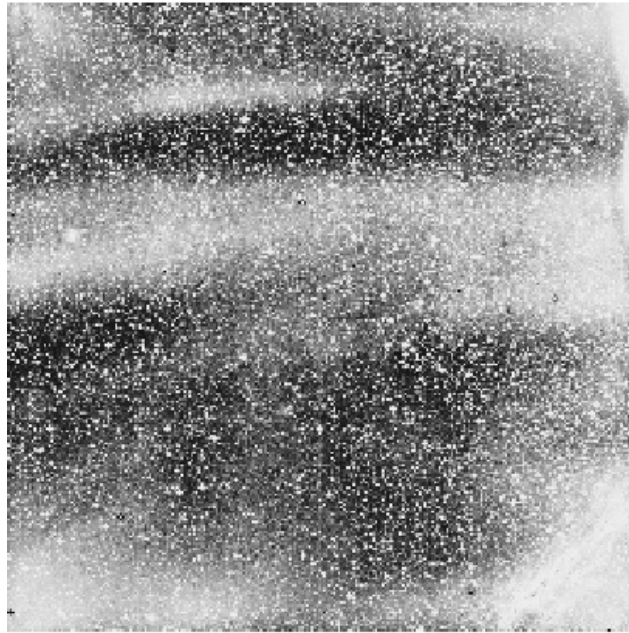


Figure 2. **Linear dark image for NIC3.**

The linear dark extension also includes the coefficients C0\_LIN and C1\_LIN, used to calculate a scaling factor, LINSSCALE, that corrects the linear dark current for its temperature dependence. The logarithm of the scaling factor is given by:

$$\log(\text{LINSSCALE}) = \text{C1\_LIN}/\text{TFBTEMP} + \text{C0\_LIN}.$$

We use this parametric form since at least in principle the dark current should be proportional to the voltage over each pixel (which can be seen as a diode) for which  $V \sim e^{1/T}$ . In the DARKCORR step `calnica` multiplies the linear dark component with LINSSCALE and exposure time before subtracting that component. Investigations of the temperature dependence of the linear dark current of the three NICMOS cameras have shown that the any detectable trend in the linear dark with temperature is smaller than the overall scatter in the dark current. Therefore, at this point no temperature dependence of the linear dark component is implemented. The coefficients are set to

$$\begin{aligned} \text{C0\_LIN} &= 0.0 \\ \text{C1\_LIN} &= 0.0 \end{aligned}$$

for all cameras (and both eras) implying that there will always be a unity scaling. The scaling factor calculated is propagated to the LINSSCALE keyword in the calibrated images (`*_cal.fits` and `*_ima.fits` files). By default, the LINSSCALE keyword is set to unity in the `*_raw.fits` files, before the DARKCORR step has been implemented.

If the `*_tdd.fits` file is present, but the TFBTEMP keyword is missing, then the scaling is set to unity, LINSSCALE=1. Similarly, if the TFBTEMP keyword exists, but has a value that is inconsistent with the expected temperature range, then the scaling is also set to unity. The valid temperature range is given by the TFBLOW and TFBHIGH keywords in the header of the linear dark extension (EXT=1) of the `*_tdd.fits` file. The current value of these keyword for the post-NCS era are (for all three cameras):

TFBLOW=60.0  
TFBHIGH=90.0.

For the pre-NCS era, both limits are set to zero, which means that no scaling will be calculated for those data.

While to date no temperature dependence of the linear dark is implemented, `calnica` is now prepared to include this should future investigations deem it necessary.

### **Amplifier glow**

The amplifier glow is a signal that is added to NICMOS images every time the cameras are read out. The signal is most likely due to radiation from the amplifiers situated in each of the four corners of the three NICMOS cameras. The amplifier glow component (normalized to one read-out) is found in the second extension (EXT=2) of the `*_tdd.fits` file given by the TEMPFILE keyword. Figure 3 shows the NIC3 amplifier glow image.

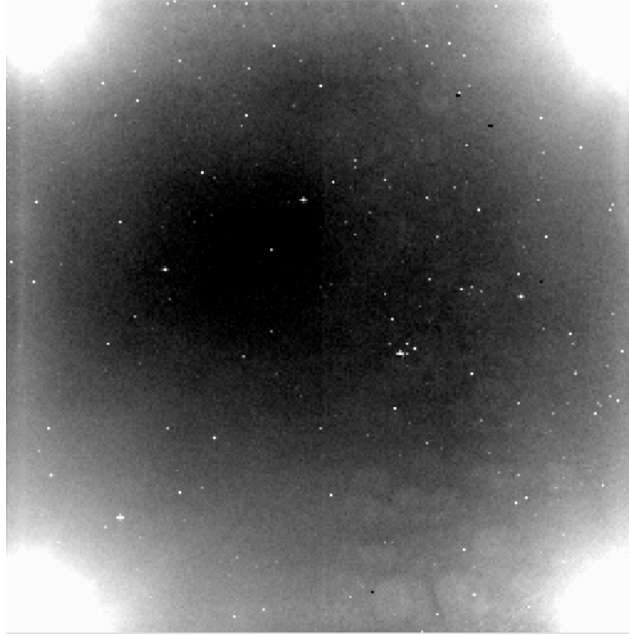


Figure 3. **Amplifier glow image for NIC3. The elevated signal in the corners from the heat of the amplifiers is clearly visible. Individual bright spots indicate hot pixels.**

In the DARKCORR step one amplifier glow image is subtracted for each read-out of the science image. Investigation of how the amplifier glow varies with temperature has found a  $\sim 2\%$  change in the signal over the  $\Delta T \sim 2\text{K}$  temperature change measured in the post-NCS era. This change is significant enough that it may affect the quality of the calibrated files, possibly leaving unwanted residuals. Therefore, a temperature dependent scaling of the amplifier glow component has been implemented in `calnica`. The scaling factor is calculated using a first order polynomial with coefficient `C0_AMP` and `C1_AMP` according to:

$$\text{AMPSCALE} = \text{C1\_AMP} * (\text{TFBTEMP} - \text{REFTEMP}) + \text{C0\_AMP}.$$

Before the amplifier glow image is subtracted from each read-out of the science image being calibrated, it is multiplied by AMPSCALE. The coefficients and reference temperatures for the three NICMOS cameras are given in Table 1 for the post-NCS data. The coefficients are also given in the header of the second extension of the `*_tdd.fits` dark reference file.

	<b>C0_AMP</b>	<b>C1_AMP</b>	<b>REFTEMP</b>
NIC1	1.0	6.586e-3	76.248
NIC2	1.0	6.991e-3	76.136
NIC3	1.0	6.079e-3	76.653

Table 1: **Coefficients for calculating the temperature dependence of the amplifier glow, post-NCS era.**

The scaling factor for the amplifier glow is propagated to the AMPSCALE keyword in the calibrated images (`*_cal.fits` and `*_ima.fits` files). By default, the AMPSCALE keyword is set to unity in the `*_raw.fits` files, before the DARKCORR step has been implemented.

For the pre-NCS era, attempts have not yet been made to derive any possible temperature dependence of the amplifier glow, therefore the coefficients for these data are set to

```
C0_AMP=1.0  
C1_AMP=0.0
```

so that the scaling is always set to unity, AMPSCALE=1.

Similar to the case of the linear dark, the scaling of the amplifier glow is set to unity if the TFBTEMP keyword is missing or is outside the expected range of temperatures valid for the post NCS era. The TFBLOW and TFBHIGH keywords applicable to the amplifier glow are found in the header of the second extension of the `*_tdd.fits` files and have values

```
TFBLOW=60.0  
TFBHIGH=90.0.
```

For the pre-NCS era, these limits are again set to zero so that no scaling is calculated even if the TFBTEMP keyword is present (as a double “security” since the pre-NCS coefficients also results in a unity scaling).

### **Shading profile**

The shading is a noiseless signal that shows up as a gradient across each of the four detector quadrants in the three NICMOS cameras. The shading is caused by a gradual change of the bias level in the pixels with time as the quadrant is read out. Figure 4 shows an example of the shading for a NIC3 image.



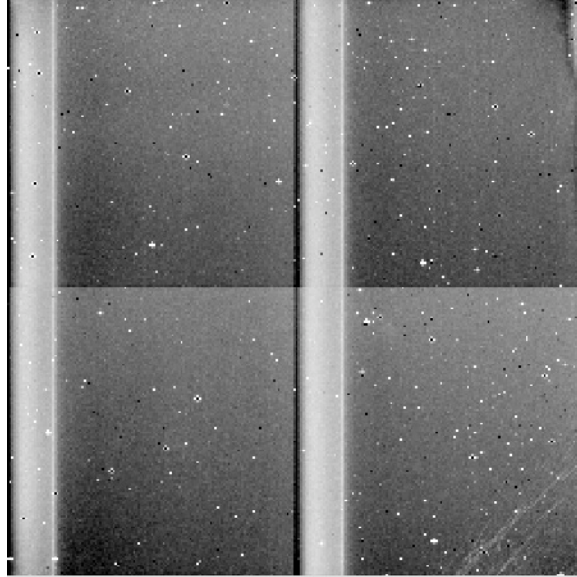


Figure 4. **The shading profile from a 256s NIC3 exposure. The individual bright spots are hot pixels.**

The shading signal varies between read-outs and depends on the time since the last read-out, which is called the DELTATIME. In total, there are twelve different DELTATIMES used by the MULTIACCUM sampling mode. The twelve different shading profiles associated with each of the DELTATIMES are described in EXT=3 to EXT=26 in the `*tdd.fits` file given by the TEMPFIL keyword. Each DELTATIME is associated with two of the extensions. One is an image of a static shading profile valid for that DELTATIME, and the other is a binary table including coefficients needed to calculate the temperature dependence of the shading correction. For more information on these files, see Jedrzejewski, 2002, NICMOS ISR 2002-005.

In the DARKCORR step of `calnica` the temperature of the detector is read and then the shading profiles for each of the DELTATIMES used in the exposure is scaled using the coefficients in the `*tdd.file` file before the shading component of the dark is subtracted.

Investigations of the pre-NCS data showed a strong correlation between the shading signal and the mounting cup temperature (Monroe & Bergeron, 1999, NICMOS ISR-99-010). Figure 5 shows an example of the NIC2 shading profile for a 64s DELTATIME readout at two different temperatures. In this case, the difference in shading signal is up to 10 counts per Kelvin.

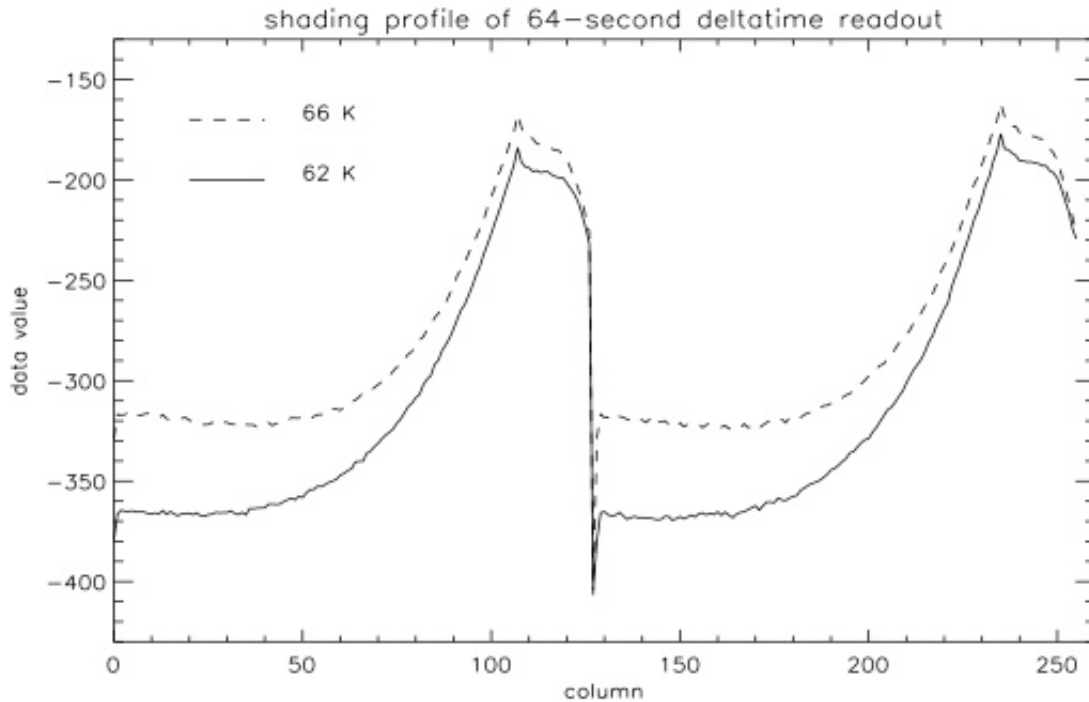


Figure 5. **Shading profiles at two different mounting cup temperatures for a 64s DELTATIME readout in NIC2. Figure taken from Monroe & Bergeron, 1999, NICMOS ISR-99-010.**

The temperature dependence of the post-NCS data has been investigated using both the bias-derived temperature and the mounting cup temperature. No significant trend in the shading profile with bias-derived temperature has been detected. If the shading was dependent on the bias-derived temperature in a similar way to the mounting cup results from the pre-NCS era, such dependence would have been easily detected since the change in bias-derived temperature is over 2K in the post-NCS era. This suggests that the shading profile does not depend to the bias-derived temperature in a similar way as does the amplifier glow and photometry. This is, however, not unreasonable since the temperature dependence of the amplifier glow and photometry are derived from external signals and therefore depends directly in the DQE, which the shading profiles does not.

We therefore use the mounting cup temperature to derive the coefficients for the temperature dependence of both the pre-NCS and post-NCS shading signal. The mounting cup temperature is given by the NDWTMP11 keyword in the `*_spt.fits` file accompanying the `*_raw.fits` file.

Note, however, that the logic of `calnica` is now written in a way that allows for the use of either the mounting cup temperature, the bias-derived temperature, or even a fixed pre-

set temperature. Which temperature to be used is decided by the settings of some of the header keywords in the `*_tdd.fits` file, as explained below. For now, `calnica` is set to use the mounting cup temperature `NDWTMP11`, but this can easily be changed if future investigations find different temperature relations. We therefore describe below the full logic of how `calnica` chooses which temperature to use.

The logic for which temperature should be used to derive the temperature dependence of the shading profile is as follows: First `calnica` checks if the `TFBTEMP` keyword is present. If not, then the `NDWTMP11` temperature is used. If it is present, then `calnica` checks if the `TFBTEMP` temperature is inside the valid range given by the `TFBLOW` and `TFBHIGH` keywords in the primary header (`EXT=0`) of the `*_tdd.fits` file. If it is inside the valid range, then `TFBTEMP` is used to scale the shading. If it is not valid, then `calnica` looks for the `TMPSETS` keyword. This keyword is set to a typical temperature value for each camera (i.e., ~median bias-derived temperature). If `TMPSETS` is not present, then the `NDWTMP11` temperature is used to scale the shading. If it is present, then `calnica` again checks if this temperature is inside then valid range given by `TFBLOW` and `TFBHIGH`. If it is valid, then `TMPSETS` is used to calculate the scaling, if not then `NDWTMP11` is used.

The current setting of the keywords involved in the logic for the shading correction is given in Table 2. The same values apply for both pre-NCS and post-NCS eras, as well as for all cameras. These settings lead to the use of the mounting cup temperature, `NDWTMP11`, in all cases even if a valid bias-derived temperature `TFBTEMP` is present. This is intended since the temperature relations are derived using the `NDWTMP11` temperature. However, if new `*_tdd.fits` file are created in the future based on the temp-from-bias, the implemented logic makes it trivial to make `calnica` use `TFBTEMP` instead by just updating the `TFBLOW`, `TFBHIGH` and `TMPSETS` keywords.

<code>TFBLOW</code>	0
<code>TFBHIGH</code>	0
<code>TMPSETS</code>	-99.9

**Table 2. Keywords in the primary header of the `*tdd.fits` reference file used to determine which temperature should be used to scale the shading component of the dark signal. The current setting of these keyword leads to the use of the mounting cup temperature, `NDWTMP11`.**

Figure 6 shows a flow-chart over the decisions made by `calnica` in the DARKCORR step in order to derive the temperature dependent dark corrections for the linear dark, the amplifier glow and the shading.

When the DARKCORR step has been completed, the DARKDONE keyword is set to PERFORMED.

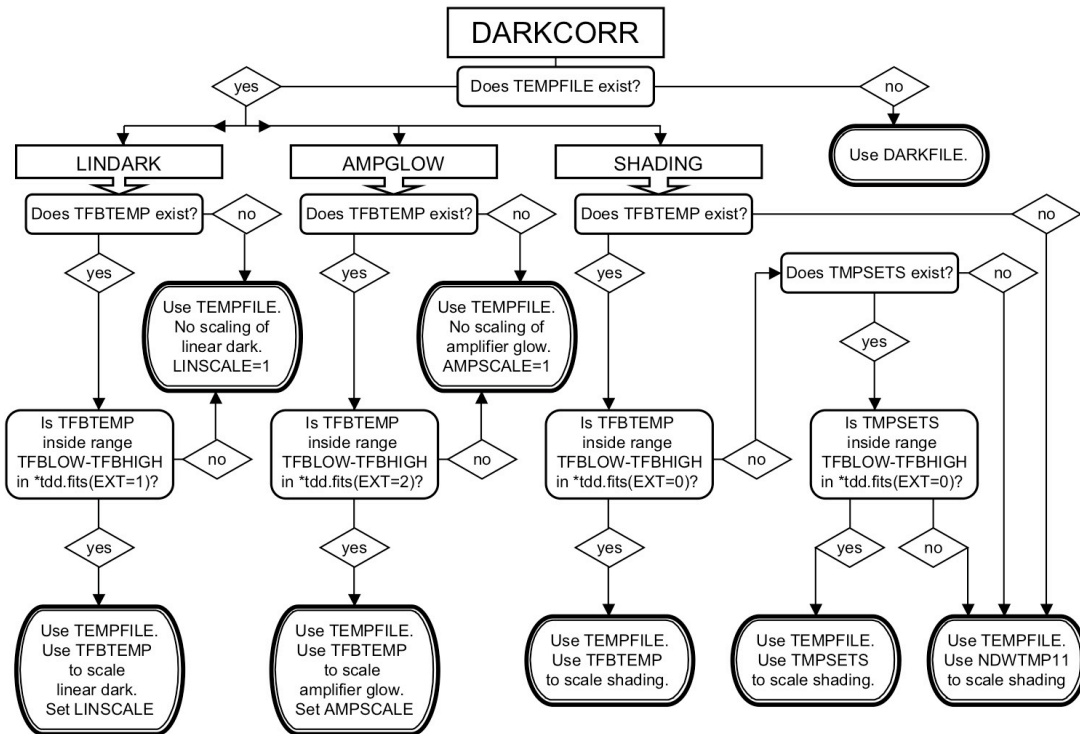


Figure 6. Flow-chart over the decisions made in the DARKCORR step of `calnica` in order to make a proper temperature scaling of the different components of the dark signal.

### Step 2 – Flat-field correction

In the FLATCORR step in `calnica`, the `*_raw.fits` images are corrected for pixel-to-pixel variations in the detector DQE by being multiplied with a flat-field image. The flat-field image is by construction normalized to unity and inverted (therefore the multiplication and not the usual division). With the temperature dependence of the DQE, the flat-fields also change. These changes are, however, of second order, i.e., any uniform DQE change over whole the detector will not affect the flat-field since such change will disappear since the flat-fields are normalized. However, these DQE changes will affect the calibration of the photometry, which we discuss in the next step. There are, however,

second order effects of the DQE changes that do affect the flat-fields. I.e., since different pixels have a relative response to temperature changes that varies depending on the individual DQE of the pixels, the structure of the flat-field changes with temperature, even though the overall normalization is unity. To account for this change in structure, a set of five different flat-fields have been created for each filter in both the pre-NCS and post-NCS eras. Each of these five flat-fields is constructed using data from a particular temperature range, and together these five ranges cover the observed temperature span for each era. Details on how these flat-fields were constructed are given in Thatte & Dahlen 2009, NICMOS ISR 2009-005.

If the FLATCORR keyword in the primary image header of the `*_raw.fits` file is set to PERFORM, then the image will be flat-fielded. The image header also contains the names of two flat-field reference files. The FLATFILE keyword points to a static reference file with extension `*_flt.fits`. This file is constructed as a normal NICMOS image with five extensions, where the flat-field is located in the first extension (EXT=1), while the other four extensions are the usual ERR, DQ, SAMP, and TIME extensions (see e.g., the NICMOS Data Handbook). The TDFFILE keyword contains the temperature dependent reference file and has an extension `*_tdf.fits`. This reference file consists of a data cub including a stack of five individual flat-fields, each valid for a particular temperature range. In total, this file therefore has 25 extensions, where EXT=1, 6, 11, 16, and 21 contain the flat-field images. The temperature range for which each extension is valid is given by the header keywords TFBLOW and TFBHIGH of that extension. The total temperature range covered by the `*_tdf.fits` file is given by the TFBLOW and TFBHIGH keywords in the primary header (EXT=0).

The TDFFILE keyword is populated in images retrieved from the HST Archive after November 19, 2008 for post-NCS data and after January 23, 2009 for the pre-NCS data. In the FLATCORR step, `calnica` checks for a valid TDFFILE in the primary header of the `*_raw.fits` file and if none is given, then the static FLATFILE will be used. If a valid TDFFILE is present, then `calnica` reads the detector temperature from the TFBTEMP keyword. Thereafter `calnica` uses this temperature to determine which of the five different flat-field extensions of the `*_tdf.fits` file to use in the FLATCORR step. Table 2 and Table 3 show the temperature ranges of the different flat-field extensions for the three different NICMOS cameras for post-NCS and pre-NCS data, respectively.

TDFGROUP	EXT	TFBLOW	TFBHIGH	TFBLOW	TFBHIGH	TFBLOW	TFBHIGH
		NIC1		NIC2		NIC3	
	0	64.95	86.85	64.65	86.80	65.60	87.05
1	1	64.95	74.95	64.65	74.65	65.60	75.60
2	6	74.95	75.55	74.65	75.30	75.60	76.08
3	11	75.55	76.25	75.30	76.15	76.08	76.56
4	16	76.25	76.85	76.15	76.80	76.56	77.05
5	21	76.85	86.85	76.80	86.80	77.05	87.05

Table 2. Temperature ranges for the five different flat-field extensions in the \*\_tdf.fits temperature dependent reference files for the post-NCS. Besides the ranges for the individual images, the full temperature range is given in the global header (EXT=0).

TDFGROUP	EXT	TFBLOW	TFBHIGH
		NIC1-NIC2-NIC3	
	0	52.00	70.00
1	1	52.00	61.40
2	6	61.40	61.80
3	11	61.80	62.20
4	16	62.20	62.60
5	21	62.60	70.00

Table 3. Temperature ranges for the five different flat-field extensions in the \*\_tdf.fits temperature dependent reference files for the pre-NCS era.

The flat-field extension that is used by calnica is written to the TDFGROUP keyword in the primary header of the calibrated files. This keyword will take a value 1 through 5 depending on detector temperature, as shown in the tables. By default the TDFGROUP keyword is set to -1 in the \*\_raw.fits file. If the TDFFILE is missing and the FLATFILE is used in the calibration instead, the TDFGROUP keyword will be set to -1 in the calibrated files. Furthermore, if TFBTEMP is missing or the temperature given by TFBTEMP is outside the values listed in the tables, then the FLATFILE will be used by calnica and TDFGROUP will again be set to -1 in the calibrated files. Figure 7 shows a flow-chart over the decisions made by calnica in the FLATCORR step in order to choose which flat-field image to use. When the flat-field step of calnica is completed, the FLATDONE keyword will be set to PERFORMED.

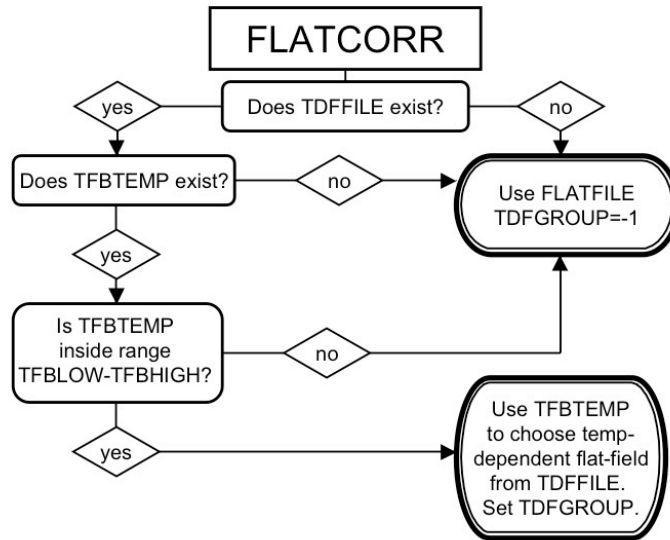


Figure 7. Flow-chart over the decisions made in the FLATCORR step of *calnica* in order to choose the correct flat-field image.

### *Step 3 –Correcting photometry*

The DQE varies with temperature for each of the three NICMOS cameras and unless corrected for, measured photometry will also vary with temperature. A detailed description of the temperature dependence of the photometry will be given de Jong 2009, NICMOS ISR, in preparation. In summary, the photometry is found to vary by a few percent over both the pre-NCS and post-NCS eras. This should be related to the  $\Delta T \sim 1\text{-}3\text{K}$  change in temperature during the same time periods.

There are two ways to correct for the change in DQE with temperature. Either the photometric zero-point can be made temperature dependent, or the image could be scaled to account for the temperature dependence while leaving the zero-point unchanged. Here we use the latter approach since using zero-points that vary with temperature will result in different zero-points for each individual NICMOS exposure. Such scenario would make it difficult to combine or dither separate images into a common image or mosaic. Instead, a scaling factor is calculated that corrects the image counts (or count rate) for the temperature dependence of the DQE and puts all images on the same zero-point (for each camera and filter combination).

The PHOTCALC step in *calnica* populates the photometry keywords appropriate for the filter and camera used during the observation. By default, this step is set to PERFORM. These keywords, which are written to the primary header of the calibrated files, can be used to retrieve the photometric zero-point in order to achieve a correct flux

calibration. The information needed to populate the photometry keywords is read from the FITS binary table given by the PHOTTAB keyword in the primary image header of the \*\_raw.fits file. These tables have extension \*\_pht.fits. Since 2009, the table also includes information needed to calculate the scaling factor that corrects for the temperature dependence of the DQE. For each camera and filter combination the PHOTTAB table lists two first order linear coefficients (PHOTF\_C0 and PHOTF\_C1) and a reference temperature (PHOTREFT). The scaling factor that corrects for DQE variations with temperature is calculated via

$$\text{ZPSCALE} = \text{PHOTF\_C1} * (\text{TFBTEMP} - \text{PHOTREFT}) + \text{PHOTF\_C0}.$$

After the scaling factor is calculated, the science extension of the NICMOS image is multiplied by this factor. The scaling factor is also assigned to the ZPSCALE keyword in the primary header. A scaling factor is only calculated when the TFBTEMP keyword is populated in the primary header of the \*\_raw.fits file. If this is not the case, the ZPSCALE keyword is set to unity. Furthermore, for temperatures outside a valid range given by the TFBLOW and TFBHIGH keywords in the primary header of the \*\_pht.fits file, the scaling is also set to unity. The values of these keywords are TFBLOW=70K (60K for pre-NCS data) and TFBHIGH=85K (70K for pre-NCS data). For the three polarizers in NIC1 and NIC2, as well as for the three grisms in NIC3, the scaling is always set to unity. Besides populating the ZPSCALE keyword, PHOTCALC step also sets the keyword PHOTFERR. This gives an estimate of the error in the zero-point due to the uncertainty in the temperature dependence of the photometry. The size of this uncertainty is typically 0.015 mag.

Figure 8 shows a flow-chart over the decisions made by calnica in the PHOTCALC step in order to correct the photometry for temperature dependence of the DQE. When this step of calnica is completed, the PHOTDONE keyword will be set to PERFORMED.



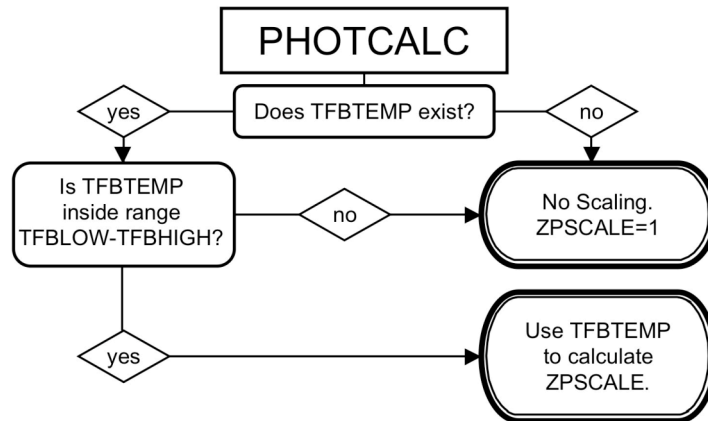


Figure 8. Flow-chart over the decisions made in the PHOTCALC step of calnica in order to calculate the ZPSCALE scaling factor that corrects images for the temperature dependence of the DQE.

## Summary

In this report we have described the logic used by the calnica reduction software to decide when to use temperature dependent reference files in order to correct for temperature dependent variations in the detector characteristics. This temperature dependence may affect the dark current, the flat-fielding and the absolute photometry. All three components of the dark signal are potentially temperature dependent, however, for the linear dark the scatter is larger than any detectable trend, so no temperature relation is introduced for that component. For the amplifier glow, a temperature dependent scaling is implemented for post-NCS data. No scaling is yet applied to the amplifier glow signal of the pre-NCS data. For the third dark component, the shading, a temperature dependent correction is done for both pre-NCS and post-NCS data. To correct for the temperature dependence of the flat-fields, a new set of reference files have been created for both pre-NCS and post-NCS data. These new flat-field files consist of a stack of five individual flat-field images each valid in a different temperature range. Calnica uses the flat-field that best matches the temperature of the science image being calibrated.

Finally, since the DQE varies with temperature in the three NICMOS cameras, corrections have to be made to derive a proper flux calibration. Calnica does this by multiplying the output science image by a temperature dependent scaling factor while keeping the photometric zero-point unchanged.

All temperature dependent corrections are calculated using the bias-derived temperature, except for the shading correction for which the mounting cup temperature is used. As a

safety measure, temperature dependent corrections are only applied if the temperature associated with an exposure lies within a predefined “normal” temperature range. If not, no temperature dependent correction is applied.

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