1997 HST Calibration Workshop
Space Telescope Science Institute, 1997
S. Casertano, et al., eds.

The NICMOS Data Handbook

Daniela Calzetti and Howard Bushouse

Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218

Abstract. The Data Handbook contains important information on the HST data GOs and GTOs receive, including explanations on the data format, on the data reduction steps performed by the automatic pipelines, on sources of uncertainties in the data, and on available tools for data analysis. The NICMOS sections of the Data Handbook will soon be available, and a draft can be already retrieved from the NICMOS WWW Documentation Page. In this Poster we present the organization of the NICMOS sections of the Data Handbook, and the relevant topics there covered.

1. Introduction

The new version of the HST Data Handbook is due to be released around mid-November 1997. This version contains for the first time the sections on the NICMOS data calibration and analysis. This Poster contains a brief description of the organization and content of the NICMOS sections.

Due to the accelerated schedule of the NICMOS observations, a large number of GOs and GTOs are receiving data *prior* to the release of the new version of the Data Handbook. For these observers, the mid-November official release date may represent a cumbersome "waiting period". In order to help NICMOS GOs and GTOs with their data analysis, a preliminary version of the NICMOS sections of the HST Data Handbook has been pre-released, and is available on the NICMOS WWW page, under Documentation, or at the direct address:

`http://www.stsci.edu/ftp/instrument_news/NICMOS/nicmos_doc.html`

It is stressed again that prior to mid-November, the WWW address contains a *preliminary* version of those sections; changes and improvements may be introduced in the final version of the Data Handbook. Observers are invited to switch to the final version of the Handbook as soon as it becomes available.

2. Organization of the NICMOS Data Handbook

The NICMOS part of the Data Handbook is divided into five chapters:

1. **Instrument Overview:** a summary of the capabilities of the NICMOS instrument on-board HST.

2. **Data Structure:** the description of the structure of the FITS files produced by NICMOS observations and by the pipeline calibration.

3. **Calibration and Recalibration:** the description of the calibration software for NICMOS observations, available both in the STScI pipeline and standalone.

4. **Error Sources:** a summary of the most common sources of uncertainty that will affect the NICMOS calibrated data, as known as of September 1997.

5. **Data Analysis:** the presentation of IRAF/STSDAS tools developed for the analysis of NICMOS data and the discussion of general topics, such as photometric calibration (see Colina & Rieke 1997), Point Spread Function subtraction, and polarimetric analysis.

3. Data Structure

A NICMOS observation produces a number of FITS files, which are delivered to the observer. The files can be both raw data and pipeline-calibrated data. A subset of these files (*_raw.fits, *_cal.fits, *_ima.fits, *_mos.fits) contain the science data proper.

An individual NICMOS science image consists of five arrays, each stored as a separate image extension in the FITS file. The five data arrays represent: 1) the science image (SCI) from the detector; 2) the error array (ERR) containing statistical uncertainties of the science data in 1σ units; 3) an array of bit-encoded data quality (DQ) flags representing known status or problem conditions of the science data; 4) an array containing the number of data samples (SAMP) that were used to compute each science image pixel value; 5) an array containing the effective integration time (TIME) for each science image pixel.

A grouping of the 5 data arrays for one science image is known as an *image set* or IMSET. A science data file can contain one or more IMSETs, depending on the readout mode used. The raw (*_raw.fits) and calibrated (*_cal.fits) science images produced by the readout modes ACCUM, BRIGHTOBJ, and RAMP contain one IMSET. The raw (*_raw.fits) and intermediate-calibrated (*_ima.fits) MULTIACCUM science images contain *N+1* IMSETs, for *N* readouts plus the zeroth readout. The calibrated (*_cal.fits) MULTIACCUM science images contain one IMSET. The science images resulting from mosaics (*_mos.fits, see next section) contain one IMSET.

4. Calibration and Recalibration

4.1. The Calibration Pipeline

The science data the observer receives are calibrated in the pipeline by at least one, and possibly two, calibration routines, `calnica` and `calnicb`. The two routines perform different operations:

1. `calnica`: performs the basic task of removing the instrumental signature from the science data. It is the first calibration step and is applied to **all** NICMOS datasets individually. The science data file input to `calnica` are the *_raw.fits files, and the outputs are the *_cal.fits and *_ima.fits files (the latter for the MULTIACCUM readout mode only).

2. `calnicb`: operates on associations of datasets. An association is created when the observer specifies a dither and/or chop pattern, and/or multiple iterations of the same exposure in the Phase 2 proposal. `Calnicb` co-adds datasets obtained from multiple iterations of the exposure; mosaics images obtained from dither patterns; background-subtracts images obtained from chop patterns. The input science data files required by `calnicb` are the calibrated files, i.e. the *_cal.fits outputs from `calnica`; the outputs are called *_mos.fits.

4.2. Calibration of Grism Observations

A separate software task, `calnicc`, has been developed in IDL by the ST-ECF to reduce NICMOS Grism observations (see Freudling 1997). The `calnicc` routines perform a series of steps devoted to identifying and extracting the spectra from the 2D images. The software currently is **not** part of the NICMOS automatic pipeline processing, and must be applied by individual users to their grism images. The spectra extraction processing can be started using `NICMOSlook`, the interactive and quick-look counterpart to `calnicc`, also written in IDL.

The user manuals, the software, and the installation instruction for `calnicc` and `NICMOSlook`, respectively, can be found at the WWW addresses:

`http://ecf.hq.eso.org/nicmos/calnicc/calnicc.html`

`http://ecf.hq.eso.org/nicmos/nicmoslook`

4.3. Recalibration

For users who wish to recalibrate their NICMOS data, `calnica` and `calnicb` are also available in STSDAS as standalone software in the `hst_calib.nicmos` package. Recalibration may be necessary in those cases when updated calibration reference files and/or software become available after the data have been processed by the pipeline. This is expecially true for data obtained during the early phases of NICMOS observations, as our understanding of the on-orbit performance of the instrument increases.

5. Error Sources

In many circumstances, calibration uncertainties will contribute to determine the quality of the final science data. For NICMOS data, calibration uncertainties may be grouped under the following categories:

- **Flatfield Uncertainties:** NICMOS flatfields are known to show significant large-scale non-uniformity, in addition to pixel-to-pixel fluctuations. The non-uniformity is also a strong function of the wavelength; at 0.8μm there is a variation of a factor $\sim$5 in the relative response across the array, which declines to a factor $\sim$3 at 2.2μm, while at 2.5μm the array is almost flat. The mean uncertainties of the flatfield response are around 4% (as of August 1997).
- **Dark Current Subtraction Errors:** the dark current proper, the dark current "pedestal", the amplifier glow, and the shading (the latter a *noiseless*, but pixel-dependent signal gradient) all contribute to affect the accuracy of the dark current subtraction from the science data. Three of the four components have been modelled and used to build synthetic darks as calibration reference files (see Bergeron & Skinner 1997). The effects of the fourth component, the "pedestal", still need full characterization before inclusion in the synthetic darks. As of August 1997, random uncertainties introduced by the synthetic darks are of the order of 1–5 DN, but systematic uncertainties appear to be larger, in the range 0–15 DN, with observed escursions to 30–40 DN.
- **Instrument Artifacts:** vignetting, effects of overexposure, intra-pixel sensitivity variations, and hot/cold pixels can affect the data analysis (e.g., photometry).
- **Cosmic Rays.**

6. Data Analysis

A number of software tools have been developed within STSDAS which can help the analysis of NICMOS data, since they have been designed to handle the multiple extensions of the

NICMOS data files, and propagate the error and data quality arrays, thus fully exploiting the information contained in the data. The tools with the most general applications are (see Busko 1997 for a more complete description of the tools):

- `msarith`: an extension of the IRAF task `imarith`, with the capability of propagating into the output file error information from both arrays and constants;
- `msstatistics`: an extension of the STSDAS task `gstatistics`, which includes error and data quality information in the computation of the statistical quantities;
- `mscombine`: a CL script which allows one to run the STSDAS task `gcombine` on NICMOS files to combine images.
- `markdq` and `ndisplay`: the first task reads the DQ array of a NICMOS image and marks the DQ flags on top of the displayed image, using different colors for different flags. `Ndisplay` combines the capabilities of the IRAF task `display` with `markdq`; it displays a NICMOS image and overlays the DQ flags according to the user-specified color code; both `markdq` and `ndisplay` are useful for locating the position of specific DQ flags, e.g. the cosmic rays rejected by `calnica` in a MULTIACCUM image.

References

Bergeron, L.E. & Skinner, C.J., 1997, this volume.
Busko, I.C., 1997, this volume.
Colina, L. & Rieke, M.J., 1997, this volume.
Freudling, W., 1997, this volume.