Quality control of VLT NACO data

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ABSTRACT

The Nasmyth Adaptive Optics System (NAOS) and the High-Resolution Near IR Camera (CONICA) are mounted at the Nasmyth B focus of Yepun (UT4) telescope of the ESO VLT. NACO (NAOS+CONICA) is an IR (1-5 micron) imager, spectrograph, coronograph and polarimeter which is fed by the NAOS - the first adaptive optics system installed on Paranal. NACO data products are pipeline-processed, and quality checked, by the Data Flow Operations Group in Garching. The calibration data are processed to create calibration products and to extract Quality Control (QC) parameters. These parameters provide health checks and monitor instrument's performance. They are stored in a database, compared to earlier data, trended over time and made available on the NACO QC web page that is updated daily.

NACO is an evolving instrument where new observing modes are offered with every observing period. Naturally, the list of QC parameters that are monitored evolves as well. We present current QC parameters of NACO and discuss the general process of controlling data quality and monitoring instrument performance.

Keywords: quality control, NACO, trend analysis, data reduction pipelines, instrument performance

1. INTRODUCTION

The Very Large Telescope (VLT) NACO instrument consists of Nasmyth Adaptive Optics System (NAOS) and the High-Resolution Near IR Camera (CONICA). It is installed in the Nasmyth B focus of the 4th VLT Unit Telescope at the Paranal Observatory in Chile and has been operated since October 2002.

NACO provides multimode, adaptive optics corrected observations in the range of $1 - 5$ μm. NAOS is an Adaptive Optics (AO) system designed to work with natural guide stars, extended objects and, in the close future, with a laser guide stars. It's unique feature is that it is capable of wave front sensing in both visible and infrared light. CONICA is an infrared imager and spectrograph. The observing modes it supports include: imaging in broad- and narrow-band filters, long slit spectroscopy, coronography with different occulting masks and polarimetry with a Wollaston prism or wire grids.

The operation of NACO follows a scheme common to all the VLT instruments[1]. The observations are obtained either in visitor or service mode. In both cases users prepare their observations defining set of observing blocks. In visitor mode user travels to Paranal Observatory to provide on-spot comments and expertise, while in the service mode the observations are executed by the night-time astronomer whenever ambient conditions match the user specifications. The visitor mode data are then packed on-site and collected by the visitor, while all the calibration frames and service mode data are transfered to ESO in Garching for further check by the Data Flow Operation Group (DFO). Here, the quality control (QC) process includes assessing the quality of the raw data (also done at Paranal), quality of products created by pipelines, as well as overseeing performance of the instrument.

Naturally, each instrument has its unique set of quality control parameters depending on design, capabilities and observing modes (see e.g. Ref.[2,3]). In case of a new and dynamic instrument such as NACO, the existing list of parameters gets modified in time due to changes in operation, detection of new instrumental effects, or introduction of new modes. Right from the beginning QC parameters are integrated into the existing system of

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data flow and quality control. In this paper we present the process by which NACO QC parameters are derived, stored and made available to the public through dedicated web sites (see also Ref.[4]). We also discuss the current, updated list of NACO QC parameters.

2. NACO QUALITY CONTROL AND TRENDING

As defined in Ref.[5] the Quality Control process performed by the DFO group in Garching includes:

- monitoring performance of the instrument
- checking the quality of the raw data
- checking quality of the pipeline products and refining the pipeline recipes

It does not include monitoring of so called QC0 parameters that mainly describe site and observing conditions like e.g. seeing, humidity, moon phase, etc. Instead, it focuses on monitoring parameters related to status of the detector, i.e. readout noise, mean dark level, the RMS of gain variations, and parameters related to observations, i.e. zeropoints, lamp efficiency, AO correction level in case of NACO, etc.

Use of pipelines is essential for efficient quality control. This is because of the large volume of the VLT data. In 2003, more than 123 GBytes of NACO raw data alone were processed. The pipelines are used to reduce the calibration data first. Not only calibration products are created but also the QC parameters are extracted. Those parameters that are monitored are archived in public database available on-line at:

http : //archive.eso.org/bin/qc1_cgi.

Some of them are also plotted as a function of time in the form of Health Check plots (Sect. 2.1) and/or Trending plots (Sect. 2.2).

Once the quality of the "master" calibration frames (Sect. 2.1) and performance of instrument are assessed, the pipeline reduces the science data. The quality of science products is checked as well. These science frames also contain useful informations concerning instrument stability and observing conditions. Thus, in the case of NACO, several QC parameters like e.g. sky brightness or image quality are extracted from science imaging products.

2.1. Quality Control of Products

We examine the products checking e.g. if they have proper flux level (over or under exposed), if they are similar to corresponding frames taken on previous nights, if they are consistent with their reference frames, if they show unusual noise pattern, etc. This is done with sets of scripts that create display of difference frames, pixel histograms, row and column plots, etc. Products that pass the inspection are archived and those that show abnormal variations are further analyzed in detail. If they contain a major flaw they are discarded. This is to assure that bad calibrations are not used for reducing science data. Bad calibrations may also indicate instrument problems and this is closely investigated.

2.2. Daily Health Check Monitor

In current VLT operation scheme the FITS files arrive from Paranal to Garching with several day delay. That creates a time gap between the QC parameters derived in Garching and the most recent ones. To assure the up-to-date coverage we include the values from the on-line pipeline processing at the Paranal. Paranal runs the very same version of pipeline as in Garching but without using best master calibration frames. Within time the data points from Paranal are replaced by the ones extracted in Garching. These daily updated plots are called Health Check plots and they can be viewed at:

http : //www.eso.org/observing/dfo/quality/ALL/daily_qc1.html

They are commonly used by day-time astronomers to check recent status of the instrument.

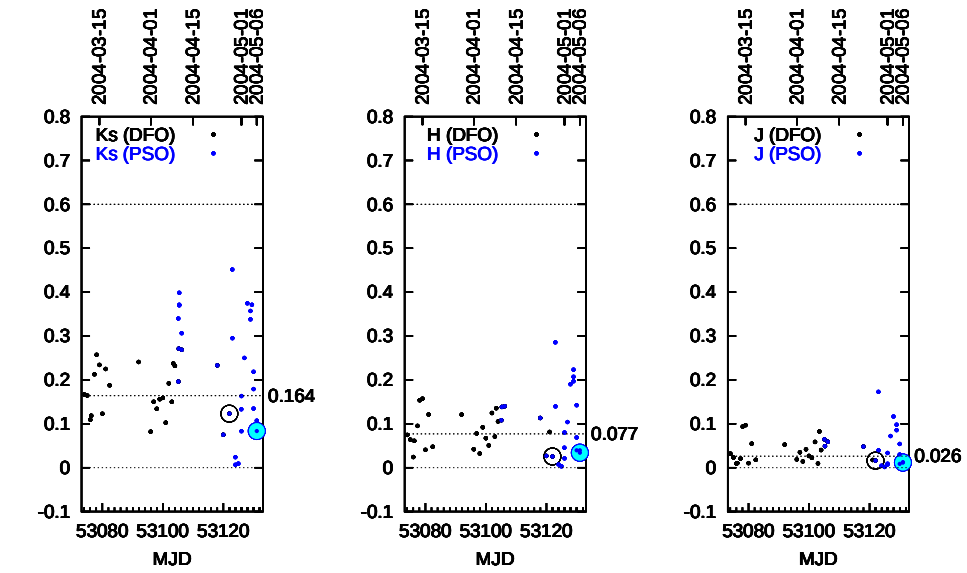

Figure 1. Example of a Health Check plot of NACO – recently modified Strehl ratio plot. Currently we consider only Strehl ratio values derived from observations of photometric standard stars with camera S27 and VIS dichroic. The three panels correspond to data points in broad band filters Ks, H and J. Grey points correspond to values from Paranal on-line pipeline runs and black points come from regular processing by QC Garching. Black and shaded circles mark the latest data points. The central bar is the mean of the black dots. The control limits are fixed to a Strehl ratio of 0.0 and 0.6, values above these limits are marked by a red circle.

The NACO QC parameters that are monitored through Health Check plots are:

- Read noise (RON) for three read out modes used with CONICA: Double ReadResetRead, Multiple Fowler-sampling and Uncorrelated
- Strehl ratio derived from photometric standard star observations obtained with camera S27 and dichroic VIS
- Photometric Zeropoints (not corrected for extinction) for three broad band filters Ks, H and J
- AO Correction
- Slit Position (will be implemented soon)

The AO Correction is a new QC parameter that monitors performance of the AO system of NAOS. Every day a special template CheckAOCorrection, and once a week more precise template CheckAOPerformance, is executed to obtain the AO corrected image of a fiber point source. We monitor Strehl ratio of the image, as well as its X and Y position. For detailed description see e.g. Ref.[6].

The Slit Position parameter will be soon included into the NACO Health Check plots. It will allow us to monitor proper position of the slit against rows and columns of the CONICA detector.

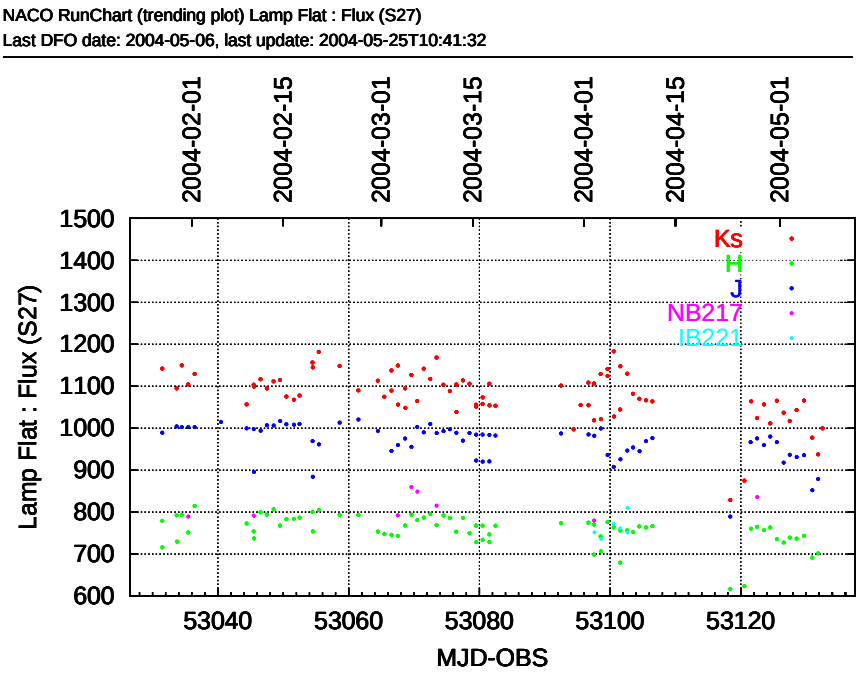

Figure 2. Example of a NACO trending plot - temporal behavior of the lamp flux extracted from the lamp flatfields obtained in camera S27. The different shades correspond to various filters in the optical path.

2.3. Trending Plots

Trending plots show the variation of QC parameters over a period of 4 months. Such a long time coverage is ideal for monitoring stability of QC parameters and detecting possible degrading of e.g. a lamp flux, or of a filter. They are displayed at:

http : //www.eso.org/observing/dfo/quality/NACO/qc/qc1.html

The following NACO QC parameters are currently trended:

- instrument temperature
- dark current
- RON (read out noise)
- number of hot pixel
- number of cold pixel
- Fixed Pattern Noise
- odd–even column effect
- gain
- sky/twilight flat histogram
- bad pixel map
- flat lamp efficiency

- twilight/sky flat flux range
- Strehl ratio
- photometric zeropoints
- image quality
- sky brightness

On 2004 May 14, a new NACO detector was installed, which will clearly reflect in the Health Check and trending plots.

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