Quality Control and Data Flow Operations of NACO

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Abstract. The verification of data and the monitoring of instrument performance - known collectively as quality control (QC) - are an integral part of the paradigm of VLT operations. This is especially true for complex instruments, such as NAOS-CONICA, which is the first adaptive optics instrument at the ESO VLT. In this paper, we discuss several of the tools we use to check and monitor instrument performance. This includes daily health checks, statistical process control, long term trending and event handling. We also present a recent example of how the QC process provided feedback to the observatory to maintain the performance of the instrument.

1 Introduction

The Nasmyth Adaptive Optics System (NAOS) [6] and the Coudé Optical and Near Infrared Camera (CONICA) [4] are installed at the Nasmyth B focus of Yepun (VLT UT4) at the Cerro Paranal Observatory in Chile. NACO (NAOS + CONICA) is the first adaptive optics system installed on Paranal and it has been offered to the community in both Service and Visitor mode since October 2002.

NACO is capable of 1-5 micron imaging, spectroscopy, coronography and polarimetry with a variety of cameras and can be used with reference stars (for wavefront sensing) as faint as V=17 and K=13. The ability to do wavefront sensing in the IR is one of the unique features of NACO.

As complex an instrument as NACO is, operating NACO is like any other VLT instrument and follows the end-to-end VLT science operations model [5]. Users prepare observations through observing blocks, the observations and the necessary calibrations, as defined in the NACO calibration plan, are taken; the data are processed by a pipeline, and both the raw and reduced data are checked.

As the last link in the chain of this model, the Data Flow Operations group (DFO) at ESO headquarters in Europe is responsible for the following tasks:

- Pipeline processing of the data.
- Assessing the quality of the raw and reduced data.
- Assessing the performance of the instrument through QC parameters.
- Building service mode packages to be delivered to service mode users [2].

In this contribution, we describe the QC process for NACO. An overview of the general QC operations model is given by [3].

2 NACO data flow

The flow of data between Paranal and Europe is the same for all VLT instruments. Each and every day, the observatory sends the pipeline logs and the FITS headers of all images that were taken during the previous 24 hours to Europe via FTP. The FITS headers are used for data classification, data volume forecast, and to extract technical QC parameters such as the temperature of CONICA detector, the pressure inside the CONICA vessel, etc. The pipeline logs contain QC parameters generated by the on-line pipeline on Paranal - zero-points and detector readout noise are two examples. These values are cross-checked against reference values and the results are posted on the web so that they are available for the day-time astronomer on Paranal.

The FITS files themselves arrive in Europe a few days later by airmail; the amount of data taken at the VLT being too great for direct transfer. The raw frames are then processed by the off-line pipeline in Europe. The NACO pipeline processes all imaging data, which corresponds to about 60% of all data taken in service mode and all calibration data. Data from some of the maintenance templates are also processed [1].

After this step, the DFO scientist inspects QC parameters and the product frames and certifies them in most cases. Certified products and QC parameters are ingested into the public archive and are available for use in later steps of the reduction cascade. QC parameters are trended and any irregularities are noted and communicated to Paranal.

The final step is to prepare the service mode package, which contains raw and reduced data and other material. This process can be triggered by a notification from the User Support Group that a particular program has been completed or by the end of an observation period, in which case all remaining uncompleted programs are packed. Partial releases of incomplete and ongoing runs can also occur at any time for operational reasons.

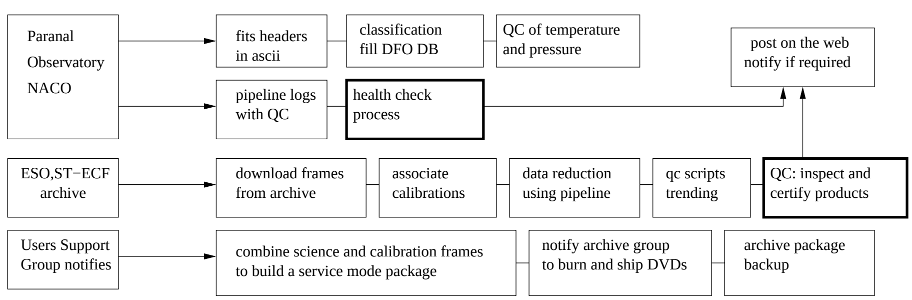

Fig. 1. The main processes of the post observation branch of the VLT dataflow

3 Quality Control

3.1 Health Check

The delay in the arrival of the FITS files from Paranal to Garching is of the order of a few days. This is a significant amount of time to loose if a problem occurs and is not detected immediately on Paranal. To catch problems early we compare the QC parameters from the on-line pipeline on Paranal with QC parameters that are derived from data that are in Garching. The resulting comparison is called a Health Check plot and this plot is available to the day-time astronomer.

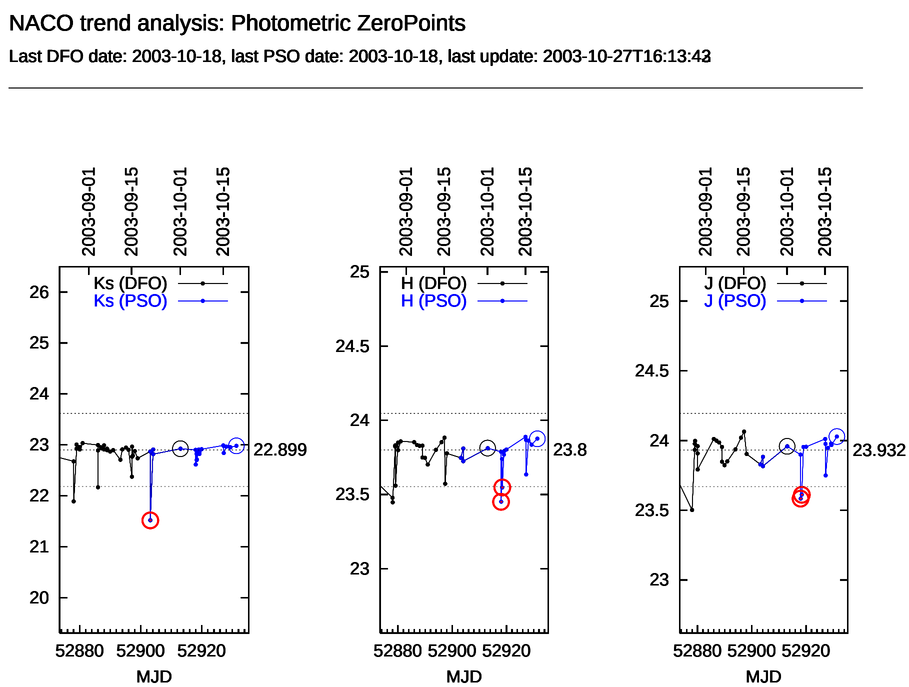

Fig. 2. Health Check plot for NACO photometric zeropoints. The black points were determined by the off-line pipeline in Garching (left most points up to the first big circle) and the blue points (right most points), which partially overlap the black ones, were determined by the on-line pipeline on Paranal. The median value and the control limits are also plotted. The presence of outliers, marked with big red circles, triggers an investigation by the DFO scientist. Most outliers are caused by cloudy weather.

3.2 QC of Products

As part of the QC process, we use scripts to analyse the processed calibration data. This involves the use of pixel histograms, row and column plots, and the direct comparison (either through division or subtraction) of calibration products with reference calibrations. This complements pipeline derived QC parameters, such as detector readout noise, but it requires some expertise on the part of the DFO scientist in deciding what is a normal variation and what is not. Products that are considered normal are archived. Products that are considered abnormal are flagged for later analysis.

3.3 Statistical Process Control Charts

We recently introduced Shewhart control charts [7], as used in industry, to standardize and improve the QC process. With few exceptions, NACO calibration data are taken as needed. This means that most calibrations are taken irregularly. Sampling with a constant time interval is therefore not feasible for most parameters, so we have adopted Moving Range control charts without subgrouping to monitor the mean and intrinsic dispersion of QC parameters.

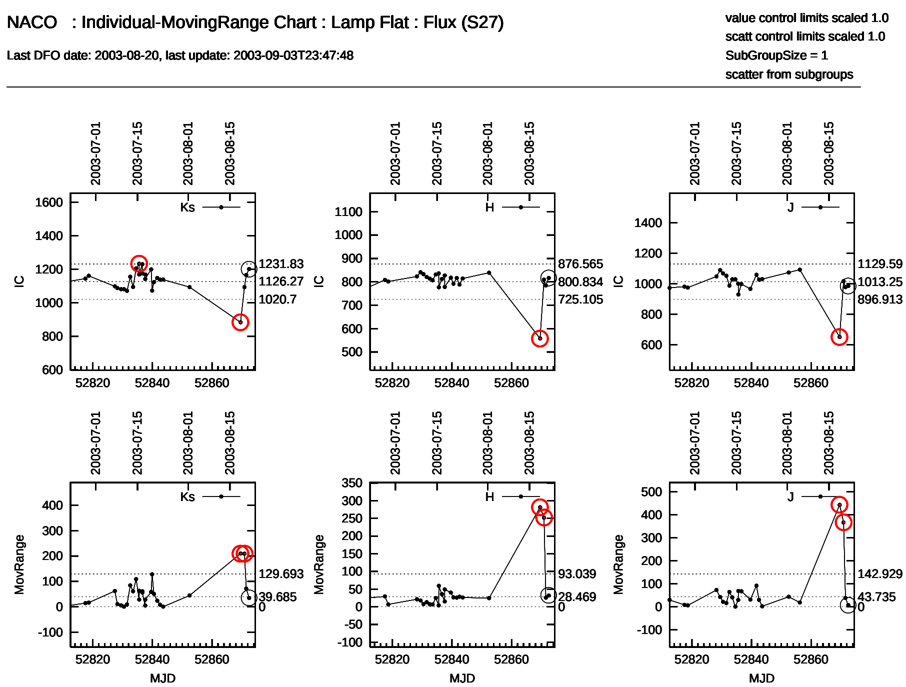

Fig. 3. Moving Range process control chart with control limits for the number of counts in a lamp flat in three filters. Upper panels show the QC parameter; lower panels show the moving range as a simple approximation to the scatter (dispersion). Marked outliers originate from test frames that were taken after an instrument intervention.

The balance between ignoring an outlier and investigating an acceptable value controls the time span (the run length) over which a parameter is analysed. Beyond the normal statistical variations we encounter the following types of outliers for NACO:

- Single outliers, mostly due to operational reasons and easy to detect because they are usually far beyond the control limit.
- Long-term trends, like dust accumulation on optical surfaces.
- Stable values, followed by an offset to a new stable value. Typically, this behavior is observed after an instrument intervention. Some parameters, like the zero level offset in detector darks, show considerable offsets.

3.4 Relations

Some QC parameters show a clear relation between other QC or system parameters. Typical examples include the measured zeropoints versus detector temperature (the warmer the detector the higher the zeropoint and the higher the dark current) or the relation between the fixed pattern noise (the noise in an unprocessed image) and flux. Another example is the reset anomaly, expressed by the zero level offset versus detector integration time (DIT). Most of these relations are empirical. They are derived from a large set of data taken over a long period of time.

3.5 Trending and Archiving

All monitored QC parameters are archived in a public database and trending plots covering a period of three months are available via the NACO QC web interface at www.eso.org/qc.

4 Event Handling Example

We show a recent (Feb 2003) event which demonstrates the interaction between QC Garching and the Paranal Science Operations team. QC Garching monitors all temperature sensors of CONICA and the QC parameters taken from dark frames as part of the calibration plan. The temperature plots (Fig. 4) show a stable detector temperature but a slow increase in the several parts of the instrument. Consequently, the background counts of the detector increased because of IR radiation coming from the instrument itself. The detailed QC plots helped to find quickly the origin of the increasing dark values and an intervention of the cooling system solved the problem. As a cross-check the RON remained stable, meaning the problem was fixed before any data were compromised.

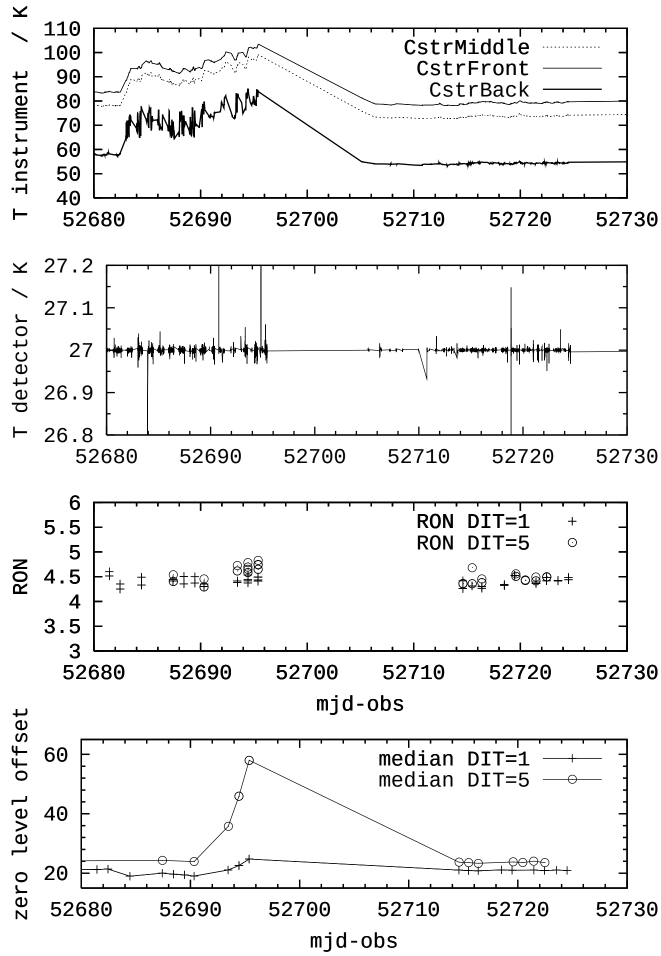

Fig. 4. Several monitored QC parameters. mjd-obs=52690 corresponds to 2003-02-19. See text for details.

References

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