# ESO Phase 3 Data Release Description

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| **Data Collection** | HAWK-I |
| **Data Provider** | James Lewis and Mark Neeser (data until September 2015) |
| | ESO, Science Data Quality group (data starting October 2015) |
| **Document Date** | 15.12.2022 |
| **Document Version** | 2.1 |

## Abstract

This data collection provides pipeline-reduced images obtained with HAWK-I, a near-infrared (0.85 – 2.5 µm) wide-field imager[1]. In 2016, the full HAWK-I archived dataset, comprising the observations from the beginning of regular operations (April 2008) until September 2015, was reduced by the Cambridge Astronomy Survey Unit (CASU) using newly developed calibration and science recipes. As of 2017, the ESO Quality Control (QC) Group took over to continue the processing of HAWK-I science data, starting with data taken in October 2015 and with further data being added at regular intervals.

This release description has two parts: the first describes the general methods applied along with details of the CASU processing. The second part describes differences in the ESO processing (applicable for observations measured post September 2015).

# Part 1: General information and CASU processing

## Overview of Observation

The data set contains all of the science observations done using the HAWK-I instrument. These are not part of a single self-contained project or survey. Rather, they contain observations from many different projects and surveys, using various filters and observing methods. The distribution of fields is obviously governed by the time of year in which the observations were taken.

## Release Content

This part of the data collection contains all of the science observations done with HAWK-I starting from 2008, and contains data up to October 2015. The content is increased beyond this date with ESO taking over the science processing of HAWK-I images (see Part 2). The first data release (April 2008 – September 2015) consists of 40,552 frames with a total size of 3.2 Tb.

From both the CASU and the ESO processing, the following data products are available for science observations:

- Stacked jittered images of the individual exposures at the detector level
- Variance arrays for the stacks
- Confidence maps for the stacks
- Single-band source catalogues for the stacks
- Fully tiled images of all of the individual exposures
- Variance arrays for the tiles
- Confidence maps for the tiles
- Single-band source catalogues for the tiles.

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[1] http://www.eso.org/sci/facilities/paranal/instruments/hawki.html

All reduction has always been done at the OB level and no attempt has been made to stack data between OBs. The following observations have been omitted:

- Observations done under any technical programme having an OBS.PROG.ID like "60" and "060" (including any standard star observations).
- Observations done in HAWK-I burst mode (DPR.CATG = "SCIENCE" and DPR.TECH = "IM-AGE,HIT").

# Release Notes

The data for this release was processed by the Cambridge Astronomy Survey Unit (CASU) using recently written science recipes that run within the ESO CPL environment. The main processing steps (applicable also to the ESO QC processing) are described in the following section.

## Data Reduction and Calibration

For all observations the following data reduction steps are performed:

- Dark correction using a master dark frame of the correct DIT/NDIT combination. By and large dark observations are done after sunrise for the DIT/NDIT combinations that have been used during the previous night. Where this has not been the case or where there was some sort of failure in the dark observation, a similar master dark frame from another night has been substituted.
- Flat fielding using a master twilight flat field for the matching filter. Twilight flat fields are changed roughly every three months during the reduction. This is so that there will be three months of data that can be stacked together in order to work out the illumination correction.
- A gain correction is applied to each detector. This is done to compensate for slight gain variations between the detectors.
- A sky background estimate is obtained and subtracted from each individual exposure. Getting this correct is just about the hardest task in infrared imaging. Because the infrared sky varies rapidly both temporally and spatially the best way to do this is to use the science images themselves to form 2d sky background images. In the case where there are large extended source in the science images, then it is often the case that offset sky exposures will have been done.
- A source catalogue is extracted for each exposure and this is used to fit a world coordinate system (WCS). The ZPN projection is used in conjunction with known projection coefficients. In general the WCS is done relative to the WISE point-source catalogue. This, in general, has a higher source density than the 2MASS PSC, which can be important for HAWK-I as the field of view is small and the instrument is generally used in regions where there are few stars. However in regions with large amounts of nebulosity the random errors in the WISE coordinates become significantly worse than for 2MASS and in such cases, 2MASS is substituted. The WCS is fitted to all four HAWK-I detectors simultaneously using the known internal geometry of the focal plane.
- The individual exposures for a single OB and a given detector are stacked using the WCS solutions defined above. The stacks are formed using a bi-linear interpolation algorithm to resample the input pixels onto the output grid. This leads to an OB stack for each detector. Note that the image stacks and tiles are re-gridded to a TAN projection. However, if a stack or tile consists of only a single exposure, then this will retain the ZPN projection.
- A single-band source catalogue is extracted from the stacked images (one for each detector).
- The source catalogue is used to redefine the WCS for the stack and to do a photometric calibration against the 2MASS PSC (see page 8 for relation between HAWK-I and 2MASS filters).
- The individual exposures for a single OB for all detectors are tiled together to form a single mosaicked image.

- A source catalogue is extracted from the tiled image.
- The tile's WCS is redefined using the above source catalogue. Also the whole tile is photometrically calibrated.
- The spatial resolution quality keywords PSF_FWHM and PSF_FERR are computed using stellar sources in each image. If the data is a multi-extension stack and there are an insufficient number of stars in the field of view of any single detector, then the average value of the other detectors is used for this keyword. Otherwise, the Paranal seeing monitor (DIMM) is used by converting its value to the different telescope size, the different waveband, and an average over the duration of the exposure. The keyword comments describe the method used.

All image products are accompanied by a variance map that has been propagated through the complete reduction cycle. Stacks and tiles also have a confidence map. Source catalogues are generated at a threshold of 1.5 times the background noise, with a minimum area of 10 pixels. The reductions were done with version 1.1.0 of the pipeline suite.

## Data Quality[2]

- The astrometric solutions are generally good to 250 milli-arcseconds, with no discernible systematic residuals, however, individual images can be slightly worse.
- There are projects that have used defocused images that give significantly worse solutions. These typically can have 500 milli-arcsecond residuals.

For all of the HAWK-I object catalogues a source-by-source match was made to the 2MASS catalogue to determine the overall astrometric and photometric quality of the images. This comparison was done using all of the 11 available HAWK-I filters (the broad band filters: Y, J, H, and Ks; as well as the narrow band filters: BrG, CH4, H2, NB0984, NB1060, NB1190, and NB2090). It was found that 82.4% of sources have magnitude differences of less than 0.1 magnitudes (92.3% have |$\Delta$m| < 0.2 magnitudes).

For both the astrometric and photometric quality it is apparent that these results are slightly worse than the internal errors of the 2MASS catalogue. The slightly larger mean internal rms can be explained by the fact that the bright catalogue stars are invariably saturated in the HAWK-I images and, therefore, only the fainter, less reliable, catalogue stars are available for calibration. A slightly better photometric result can be achieved by limiting the matching to the core broad-band HAWK-I filters.

For the entire reprocessing release, these results are summarised in Table 1 and Figures 1 & 2.

| Astrometric and Photometric Accuracies | |
|---|---|
| median $\Delta\alpha * \cos(\delta)$ | 0.0 +/- 0.2 arcsec |
| median $\Delta\delta$ | 0.0 +/- 0.2 arcsec |
| median $\Delta$mag | 0.0 +/- 0.2 magnitudes |

**Table 1:** a summary of the results that match the HAWK-I tile source lists with the 2MASS catalogue.

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[2] Based on investigations done with the CASU processing results for observations from April 2008 to September 2015
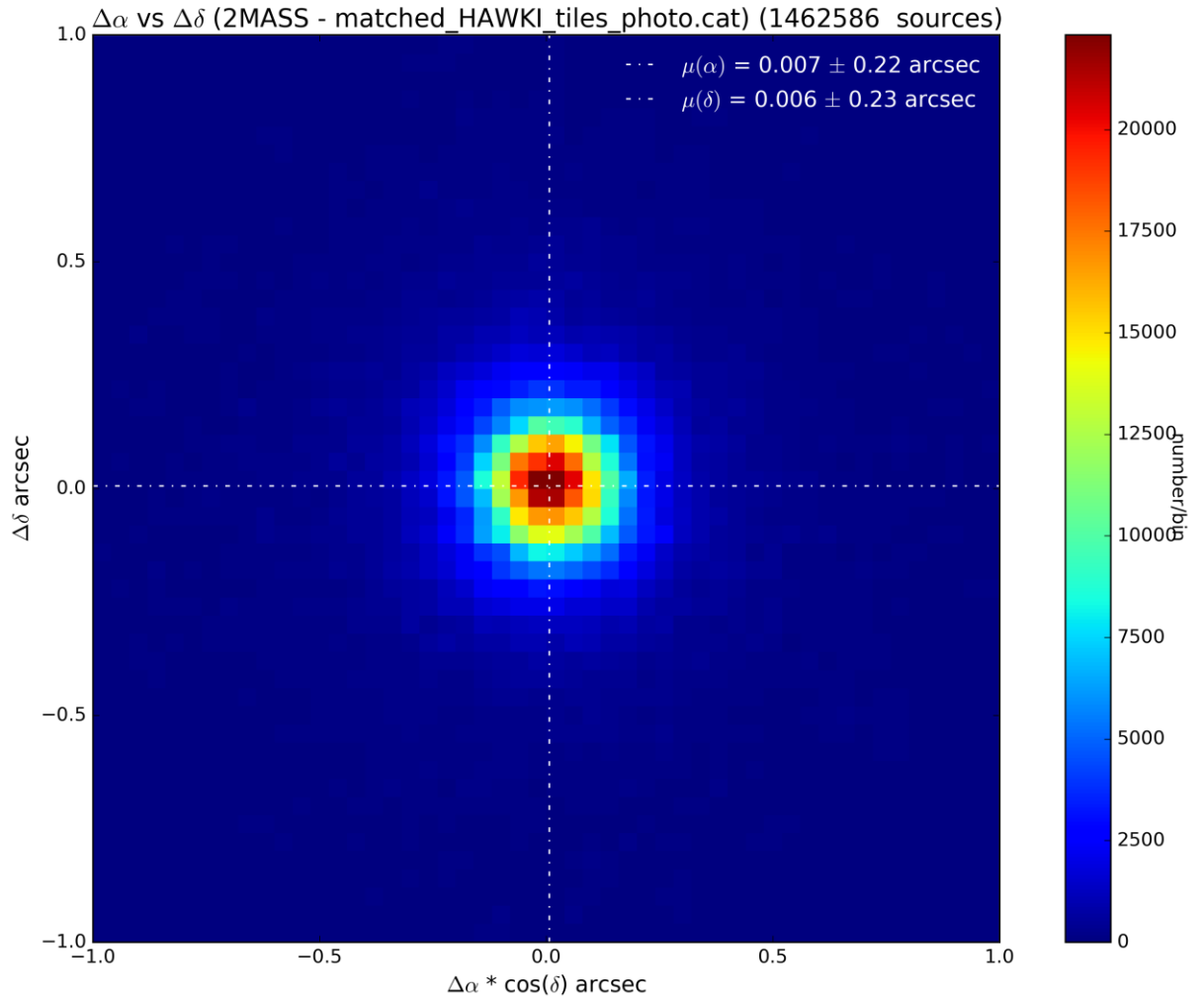
**Figure 1:** the astrometric quality of the HAWK-I reprocessed tiles as measured by comparing the HAWK-I source lists with the 2MASS catalogue. The standard deviation of the Δα*cos(δ) and Δδ distribution is 0.2 arcsec. This is close to the accuracies of the 2MASS point source catalogue.
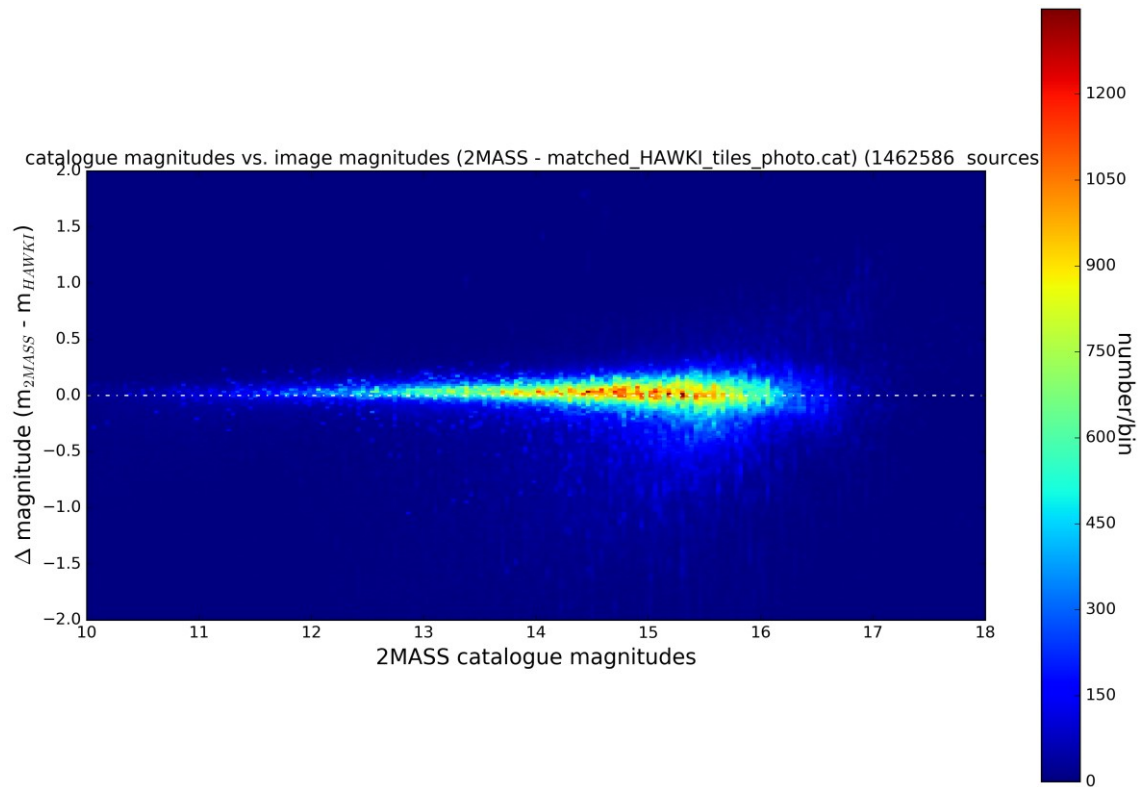
**Figure 2:** A magnitude – Δmagnitude density plot showing the photometric quality of the HAWK-I source catalogues. The data is derived from sources in all 11 filters from reprocessed HAWK-I tiles matched with 2MASS catalogue stars. The standard deviation of the magnitude difference distribution is 0.2 magnitudes, with 80.8% of sources having |Δm| < 0.1 magnitudes and 92.0% of sources having |Δm| < 0.2 magnitudes.

## Known issues
None known

## Previous Releases
None

# Data Format

## Files Types
In case of the CASU processing for data obtained until September 2015, the files are generally named after the raw files they are derived from. In the case of stacks or tiles, the name is derived from the first raw file included in the combined file. Below are examples of the file names that may be created from a given OB. The first raw file in this OB was called HAWKI.2013-08-02T03:17:00.146.fits:

- HAWKI.2013-08-02T03:17:00.146_st.fits – the stacked exposures from the whole OB (one stack per detector).
- HAWKI.2013-08-02T03:17:00.146_st_var.fits – the variance map for the stack
- HAWKI.2013-08-02T03:17:00.146_st_conf.fits – the confidence map for the stack
- HAWKI.2013-08-02T03:17:00.146_st_cat.fits – the source catalogue for the stack
- HAWKI.2013-08-02T03:17:00.146_ex_tl.fits – the full tile for the OB with all detector images combined onto a single output grid
- HAWKI.2013-08-02T03:17:00.146_ex_tl_var.fits – the variance map for the full tile
- HAWKI.2013-08-02T03:17:00.146_ex_tl_conf.fits – the confidence map for the full tile
- HAWKI.2013-08-02T03:17:00.146_ex_tl_cat.fits – the source catalogue for the full tile

For a description of the nomenclature of files from the ESO QC processing please see page 14.

With the exception of the tile products all of these are delivered as a single multi-extension FITS files with each detector being represented as an image or binary table extension. The ordering of the extensions is as it is in the raw files with the detectors represented in the order 1,2,4,3. The primary header unit has just header information that is relevant to the exposure or the stack as a whole. Tile image products are represented as a simple FITS file, whereas the tile catalogue is represented as a single binary FITS table extension.

## Catalogue Columns

**Table 2**. Catalogue columns (CASU and ESO QC products)

| Col # | Name | Description |
|---|---|---|
| 1 | Sequence_number | Running number for ease of reference, in strict order of image detections |
| 2 | Isophotal_flux | Standard definition of summed flux within detection isophote. |
| 3 | X_coordinate | The $x, y$ coordinates and errors with (1, 1) defined to be the centre of the first active pixel in the image array. |
| 4 | X_coordinate_err | |
| 5 | Y_coordinate | |
| 6 | Y_coordinate_err | |
| 7 | Gaussian_sigma | Second moment parameters |
| 8 | Ellipticity | |
| 9 | Position_angle | |
| 10 | Areal_1_profile | The number of pixels above a series of threshold levels, relative to local sky. The levels are set at T, 2T, 4T, 8T, 16T, 32T, 64T and 128T where T is the analysis threshold |
| 11 | Areal_2_profile | |
| 12 | Areal_3_profile | |
| 13 | Areal_4_profile | |
| 14 | Areal_5_profile | |
| 15 | Areal_6_profile | |
| 16 | Areal_7_profile | |
| 17 | Areal_8_profile | |
| 18 | Peak_height | Peak intensity and its error in ADU relative to local value of sky |
| 19 | Peak_height_err | |
| 20 | Aper_flux_1 | Flux and error within a specified radius aperture, typically set so that $R_{aperture} = \langle FWHM \rangle$ where the quantity in angle brackets is the mean FWHM of all stellar images. This is also known as the "core radius". The apertures here correspond to (0.5, $1/\sqrt{2}$, 1, $\sqrt{2}$, 2, $2\sqrt{2}$, 4, 5, 6, 7, 8, 10, and 12) times the core radius. |
| 21 | Aper_flux_1_err | |
| 22 | Aper_flux_2 | |
| 23 | Aper_flux_2_err | |
| 24 | Aper_flux_3 | |
| 25 | Aper_flux_3_err | |
| 26 | Aper_flux_4 | |
| 27 | Aper_flux_4_err | |
| 28 | Aper_flux_5 | |
| 29 | Aper_flux_5_err | |
| 30 | Aper_flux_6 | |
| 31 | Aper_flux_6_err | |
| 32 | Aper_flux_7 | |
| 33 | Aper_flux_7_err | |
| 34 | Aper_flux_8 | |
| 35 | Aper_flux_8_err | |
| 36 | Aper_flux_9 | |
| 37 | Aper_flux_9_err | |
| 38 | Aper_flux_10 | |
| 39 | Aper_flux_10_err | |

| | | |
|---|---|---|
| 40 | Aper_flux_11 | |
| 41 | Aper_flux_11_err | |
| 42 | Aper_flux_12 | |
| 43 | Aper_flux_12_err | |
| 44 | Aper_flux_13 | |
| 45 | Aper_flux_13_err | |
| 46 | Petr_radius | Petrosian radius, $r_p$ in pixels as defined in Yasuda, et al. 2001, AJ, 112, 1104. |
| 47 | Kron_radius | Kron radius, $r_k$ in pixels as defined by Bertin and Arnouts 1996, A & A Supp, 117, 393. |
| 48 | Hall_radius | Hall radius, $r_h$ in pixels as defined by Hall and Mackay 1984, MNRAS, 210, 979. |
| 49 | Petr_flux | Petrosian flux and error to $2r_p$ |
| 50 | Petr_flux_err | |
| 51 | Kron_flux | Kron flux and error to $2r_k$ |
| 52 | Kron_flux_err | |
| 53 | Hall_flux | Hall flux and error to $5r_h$. Alternative total flux |
| 54 | Hall_flux_err | |
| 55 | Error_bit_flag | Bit pattern listing various processing error flags. Currently this is the number of bad pixels included in the aperture flux (Aper_flux_3) |
| 56 | Sky_level | Local interpolated sky level from background tracker |
| 57 | Sky_rms | Local estimate of variation in sky level around images |
| 58 | Parent_or_child | Flag for parent or part of de-blended deconstruct |
| 59 | RA | RA and Dec of each object in degrees |
| 60 | Dec | |
| 61 | Classification | simple flag indicating most probable classification for object: **-2:** Object is compact (maybe stellar) **-1:** Object is stellar **0:** Object is noise **1:** Object is non-stellar |
| 62 | Statistic | an equivalent N(0,1) measure of how stellar-like an image is. It is used in deriving the classification in a "necessary but not sufficient" sense. This statistic is computed from a discrete curve-of-growth analysis from the peak and aperture fluxes and also factors in ellipticity information. The stellar locus is used to define the "mean" and "sigma" as a function of magnitude such that the "statistic" can be normalised to an approximate N(0,1) distribution. |
| 63-80 | blank | |

Converting the source catalogue fluxes (here, using any of the 13 aperture flux values: *Aper_flux_1* to *Aper_flux_13*) to magnitudes can be done with the following relation:

**magnitude = PHOTZP - 2.5\*log₁₀(Aper_flux_i) - APCORi        (for i = 1 . . . 13)**

where uppercase parameters indicate header keywords:

PHOTZP        = the photometric zeropoint [magnitude]

APCORi          = the stellar aperture correction for i[th] aperture flux [magnitude]

## Colour transformation

HAWK-I and 2MASS filters relate as follows:

$$Y_{HAWKI} = 1.52 * J_{2MASS} - 0.52 * H_{2MASS}$$
$$J_{HAWKI} = 0.85 * J_{2MASS} + 0.15 * H_{2MASS}$$
$$H_{HAWKI} = 0.06 * J_{2MASS} + 0.94 * H_{2MASS}$$
$$Ks_{HAWKI} = 0.03 * J_{2MASS} + 0.97 * K_{2MASS}$$
$$CH4_{HAWKI} = 0.06 * J_{2MASS} + 0.94 * H_{2MASS}$$
$$H2_{HAWKI} = 0.03 * J_{2MASS} + 0.97 * K_{2MASS}$$
$$BrG_{HAWKI} = 0.03 * J_{2MASS} + 0.97 * K_{2MASS}$$
$$NB1060_{HAWKI} = 1.50 * J_{2MASS} - 0.50 * H_{2MASS}$$
$$NB1190_{HAWKI} = 0.85 * J_{2MASS} + 0.15 * H_{2MASS}$$
$$NB0984_{HAWKI} = 1.62 * J_{2MASS} - 0.62 * H_{2MASS}$$
$$NB2090_{HAWKI} = 0.03 * J_{2MASS} + 0.97 * K_{2MASS}$$

# Part 2: ESO processing

## Differences in data processing to CASU

This part describes differences in the ESO processing, applicable to observations measured in October 2015 and later.

### Data selection

The processing is carried out for input data sets with at least four files because the background estimation is usually rather poor in such cases and resulting stacked images show significant artefacts.

### Data reduction

**Master calibrations.** Master calibration products are regularly created from all measured calibrations. They are quality-reviewed and certified. The closest-in-time certified calibrations are taken for the science reduction. Master darks (matching the DIT/NDIT combination of the science data) are typically measured within 24 hours from the science observation. A suitable twilight flat field (matching the filter) is usually available within ±21 days.

**Source catalogue.** For fitting world coordinate systems (WCS), preference was given to 2MASS vs. WISE because the intrinsic accuracy is higher and the risk for ambiguity during source detection in crowded fields is much lower. In very few cases, source detection and therefore data reduction is impaired because the lower density of sources in 2MASS leads to an insufficient number of detections within a certain field. These observations have been processed again, this time using the WISE catalogue. If this is the case, a comment has been added in the QC_COMM<n> header keywords in the products.

**Photometric calibration.** Photometric calibration is always done using 2MASS (as for CASU). In a few rare cases, neither photometric standard stars could be identified nor a default photometric calibration could be applied. The corresponding data have not been included in the collection.

**Pipeline version.** The initial data processed by the ESO QC group was created with pipeline version 2.1.1. The actual version can be found in the headers of the product FITS files in the keyword "PROCSOFT".

## Added information

### Products

The same pipeline products as for CASU are delivered. Stacked and tiled images have some header keywords added with information related to the OB and to the Quality Control (QC) process (see Table 3).

**Table 3.** Added Fits keywords

| Keyword | Values | Description |
|---|---|---|
| *OB related information:* | | |
| VM_SM | 'VM' or 'SM' | Data taken in Service Mode of Visitor Mode. VM data are less constrained in terms of OB properties, they have no user constraints defined and therefore no OB grades |
| OB_GRADE | 'A', 'B', 'C', 'D', or 'X' | Immediate grade[3] given by the night astronomer, considering ambient conditions checked against user constraints |
| OB_COMM<n> | Free text | Any optional comments added by the night astronomer, together with the approximate UT hh:mm (truncated after 200 characters) |
| *QC related information:* | | |
| QCFLAG | e.g. '0000000' | QC flag composed of seven bits, see Table 4 |
| QC_COMM<n> | Free text | Optional comments added during the review of the pipeline products |

## QC flag

The header key "QCFLAG" in the HAWK-I image products describes automatically assigned quality flags. It is comprised of seven bits (see Table 4). For each bit, the value "0" means "no concern", i.e. a value of "0000000" for the QC flag indicates that no potential issues have been found.

Flags #1 and #2 assess the quality of the data processing. Flag #1 is set when less exposures than originally intended have been executed (TPL EXPNO < TPL NEXP for the last input raw file). This means that the observation is not as deep as planned. Also, additional executions of the same OB may exist in order to compensate for this. Note that such cases are processed separately; there has been no attempt to stack exposures from different executions of the same OB.

Flag #2 is set when the time difference to the applied master twilight flat is larger than 21 days, the frequency according to the calibration plan. A minor violation is usually not an issue because flats are reasonably stable but large time differences may, nevertheless, indicate a potential problem with flat fielding during the reduction.

Flags #3 to #7 are related to the quality of the product. The HAWK-I detector pixels become non-linear if they are exposed beyond 25000 ADUs. Due to detector defects, some pixels are always classified as "bad"; in a typical exposure, the total number of these "bad" pixels is below 10000. If this is not the case then flag #3 is set. This could indicate that there are over-exposed sources in the observation.

In almost all exposures, some standard stars for the photometric calibration could be found within the 2MASS catalogue. If this is not the case then flag #4 is set.

The typical accuracy of the astrometric calibration is better than about 0.3 arcsecs. This is similar to the intrinsic accuracies of the 2MASS stars. Higher errors are indicated by flag #5.

The pipeline reports the image quality as the average FWHM of star-like sources. While large values can be due to poor weather conditions, very low values for non-AO observations could indicate that (detector) artefacts have been falsely identified as sources. Flag #6 is, therefore, set when the reported average image quality is below 0.3 arcsec. This can occur when there are very few stars in the field and the detections are dominated by detector defects.

Finally, bit #7 is related to the optical quality of the observation and flags measurements where the average ellipticity is above 0.25.

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[3] 'A': fully within constraints. 'B': some constrains up to 10% violated. 'C': out of constraints. 'D': out of constraints, do not repeat. VM data are formally graded 'X' meaning 'unknown'

**Table 4.** QC flags

| Bit | Content (if YES value is 0, otherwise 1) | Motivation | Header keys[4] (HIERARCH ESO …) |
|---|---|---|---|
| #1 – template complete | Template completely executed? | If not, intended depth of the observation may not be reached; further exposures may exist to compensate | TPL EXPNO, TPL NEXP |
| #2 – Δt to twilight flat | Time difference to applied twilight flat < 21 days? | If not then this means a potential issue with flat-fielding | None |
| #3 – non-linear pixels | Number of pixels having more than 25000 ADU in first raw file below 10000? | High numbers of non-linear pixels indicate saturated sources | None |
| #4 – number of photometric standards | Standard stars for zeropoint calculation found in FOV? | If not then a default zeropoint is written to the product headers | QC MAGNZPT |
| #5 – error on WCS | Error on WCS < 0.3 arcsec? | A higher error may indicate an issue with the WCS fit | DRS STDCRMS |
| #6 – image quality | Image quality > 0.3 arcsec? | For non-AO data, a small value indicates that artefacts have been falsely identified as astronomical sources | QC IMAGE_SIZE |
| #7 – ellipticity | Ellipticity of stellar sources < 0.25? | High ellipticity could indicate a problem with the instrument focus or guiding | QC ELLIPTICITY |

## Previews

The preview plots have been originally developed as quick-look plots for the process quality control. It was felt that they might also be useful for the archive user. They are delivered as ancillary files along with the main products. There is one preview associated to a tiled image (combining all four quadrants, see Fig. 3) and four plots for a jittered product (one plot per quadrant, see Fig.4).

## Process quality control

The quality of the data reduction is monitored with quality control (QC) parameters which are stored in a database. They are publicly accessible through a browser[5] and a plotter[6] interface. A subset of these parameters is evaluated for the QC flag (see above).

Figure 5 is an example plot that can be derived from QC parameters. It shows the error of the WCS versus the number of stars used for the WCS fit. The threshold used for the score bit #5 is indicated by a horizontal line. Most fields have WCS error below this threshold.

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[4] In the image and catalogue product files. The keywords "QC IMAGE_SIZE" and "QC ELLIPTICITY" are only written to the catalogues

[5] Browser: http://archive.eso.org/qc1/qc1_cgi?action=qc1_browse_table&table=hawki_science_idp

[6] Plotter: http://archive.eso.org/qc1/qc1_cgi?action=qc1_plot_table&table=hawki_science_idp
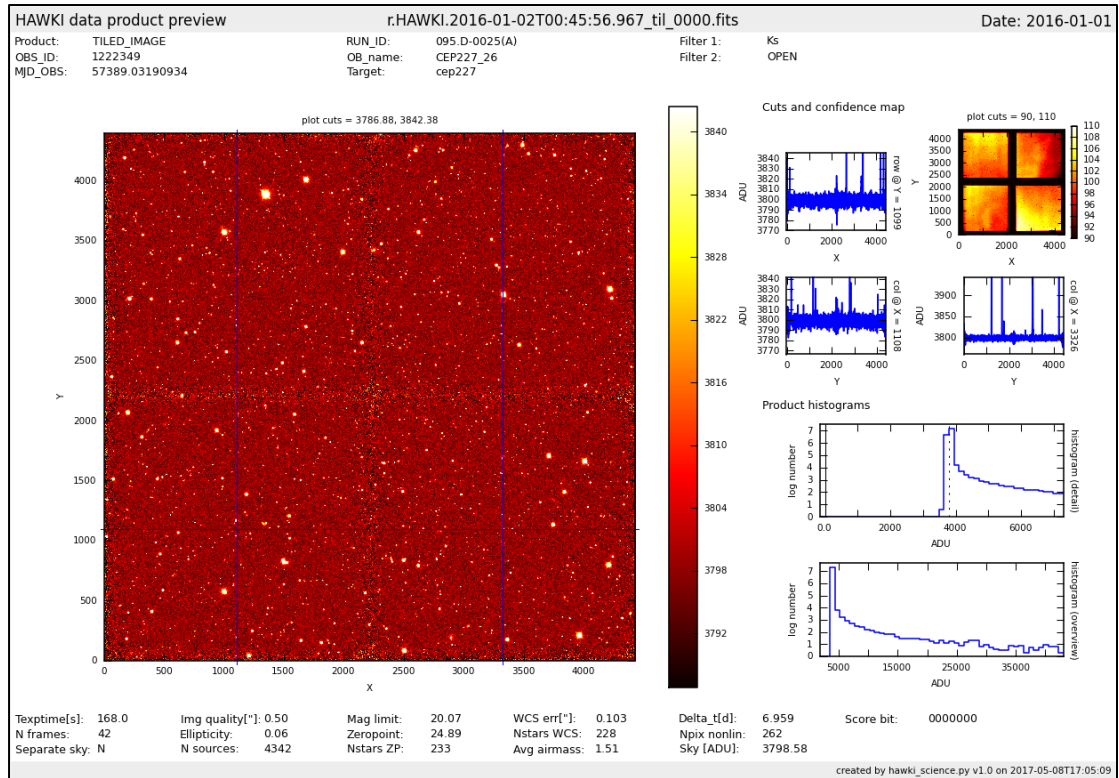
**Figure 3**. Preview plot associated to a tiled product. It has an overview of the complete image, the confidence map associated to this image (upper right), three cuts through the image (which are also indicated as blue lines in the overview image), and two product histograms (one around the residual background level and one for the overall distribution). At bottom, a set of QC parameters applicable to the product are printed: Texptime (total exposure time of the stack, from header keyword "EXPTIME"), N frames (number of input raw frames, from header keyword "PRO DATAN-COM"), Separate sky ('Y' if a separate sky exposure exists), Img Quality (average FWHM of star-like sources, from "QC IMAGE_SIZE"), Ellipticity (average ellipticity of star-like sources, from "QC EL-LIPTICITY"), N sources (total number of identified sources), Mag limit (limiting magnitude, from "QC LIMITING_MAG"), Zeropoint (photometric zeropoint for this observation, from "QC MAGZPT"), Nstars ZP (number of standard stars used for zeropoint calculation, from "QC MAGNZPT"), WCS err (error of the world coordinate system, from "DRS STDCRMS"), Nstars WCS (number of stars used for fitting the WCS, from "DRS NUMBRMS"), Avg airmass (average airmasse during observation of the stack), Delta_t (time difference to applied twilight flat), Npix nonlin (number of non-linear pixels), Sky (average sky value, from "QC MEAN_SKY"), and the score bit. On top, some keyword values extracted from the product header are printed
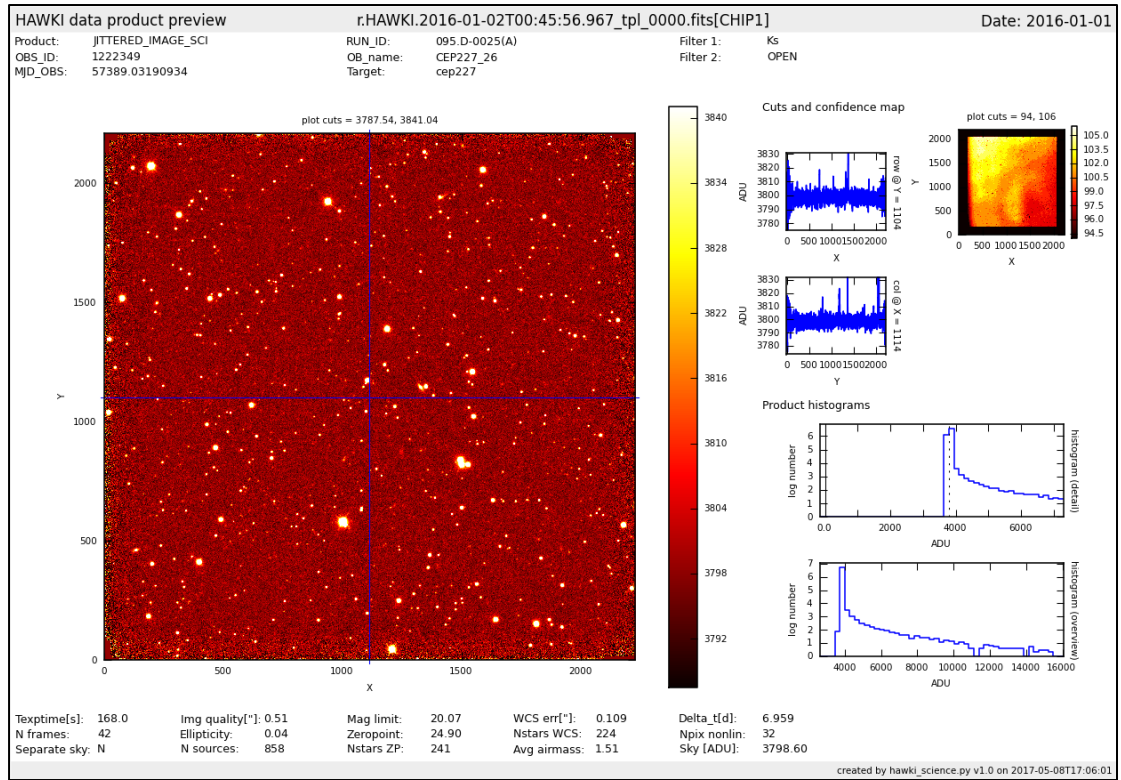
**Figure 4.** Preview plot associated to a jittered stack. It comes per quadrant. Content is basically the same as for the tile except that only two cuts are drawn. The score bit has been omitted since it is only applicable to the tile
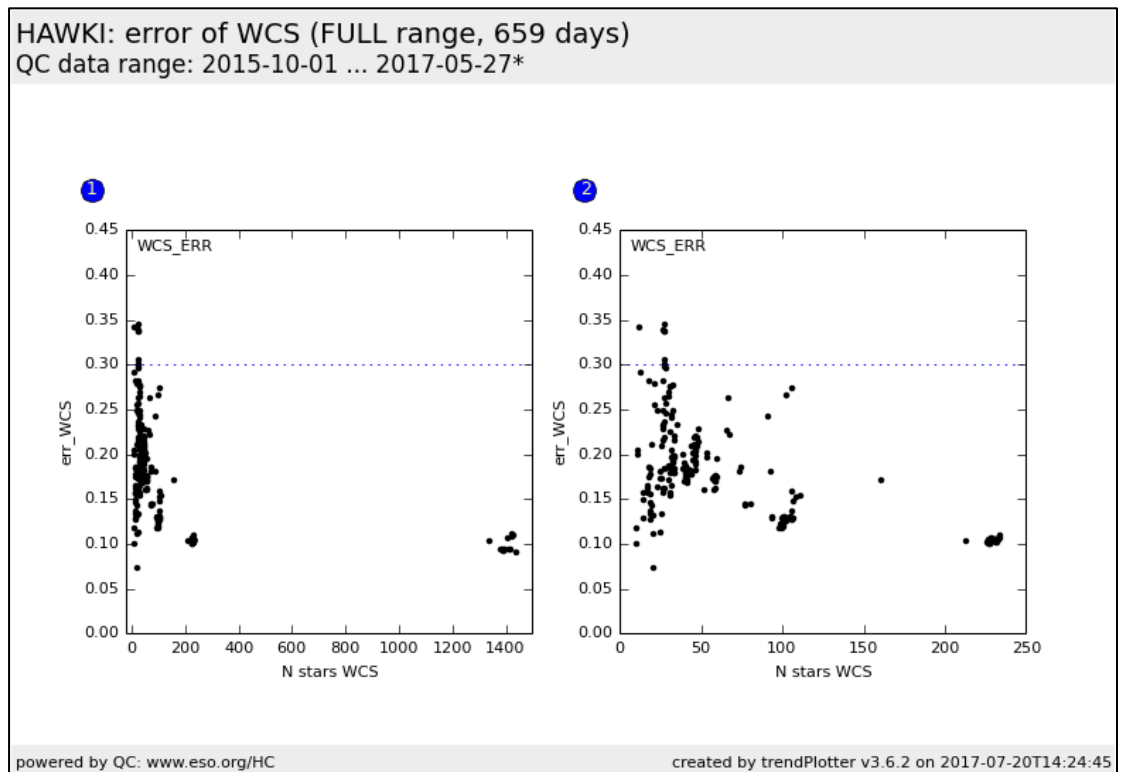


**Figure 5.** Error of the WCS fits versus number of stars used in the fit. The plot comprises of data from all observations executed between October 2015 and May 2017. The left panel shows the complete sample, the right panel a close up

13

# Data Format

## Files Types

There are four primary product files and four ancillary fits files for each data set. Table 5 gives an overview of them. Their ORIGFILE product names follow this naming convention[7]:

        HI_<TYPE>_<OBS_ID>_<DP_ID>_f1<FILT1>_f2<FILT2>_AO|NOAO.fits

See Tables 5 and 6 for details. An example ORIGFILE name would be

        HI_SOBJ_1864109_2018-01-06T07:47:23.427_f1Ks_f2OPEN_AO.fits

for a jittered image from OB 1864109, observation started at 07:47:23.427 UT on 6 January 2018 and was executed using the Ks filter and adaptive optics. The user may wish to read the ORIGFILE header key and rename the archive-delivered fits files accordingly.

**Table 5.** Primary and ancillary fits products

| ORIGFILE begins with | Product category HIERACH ESO PRO CATG | Format | Primary or ancillary? | Description |
|---|---|---|---|---|
| HI_SIMJ | JITTERED_IMAGE_SCIENCE | Image, 4 extensions | Primary | Stacked exposure |
| HI_SOBJ | OBJECT_CATALOGUE_JITTERED | Table, 4 extensions | Primary | Source catalogue for the stack |
| HI_SVAJ | JITTERED_VAR_IMAGE | Image, 4 extensions | Ancillary | Variance map for the stack |
| HI_SCFJ | CONFIDENCE_MAP_JITTERED | Image, 4 extensions | Ancillary | Confidence map for the stack |
| HI_SIMT | TILED_IMAGE | Image | Primary | Full tile with combined detectors |
| HI_SOBT | TILED_OBJECT_CATALOGUE | Table | Primary | Source catalogue for the tile |
| HI_SVAT | TILED_VAR_MAP | Image | Ancillary | Variance map for the tile |
| HI_SCFT | TILED_CONFIDENCE_MAP | Image | Ancillary | Confidence map for the tile |

**Table 6.** ORIGFILE naming convention

| Component | Description |
|---|---|
| HI | HAWK-I product |
| <TYPE> | Products type, see Table 5 for complete list; 'S' stands for science, 'J' and 'T' for jittered or tiled |
| <OBS_ID> | OB ID of the observation (header key HIERACH ESO OBS ID) |
| <DP_ID> | Time stamp in UT of the first exposure of the stack in the format <YEAR>-<MONTH>-<DAY>T<HOUR>:<MINUTE>:<SECOND>.<MILLISECOND> |
| <FILT1> | Name of filter in first filter wheel ('OPEN': no filter) |
| <FILT2> | Name of filter in second filter wheel ('OPEN': no filter) |
| AO|NOAO | Usage of adaptive optics (AO): 'AO' (AO was used during observation) or 'NOAO' (AO was not used). File names with the 'AO|NOAO' string come from observations without AO, which was always the case before January 2018 |

In addition to the fits products, also the preview plots are delivered as ancillary files. They come in the PNG image format and follow the naming convention

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[7] In case of the ESO QC processing applicable for observations from October 2015 onwards. For a description of the nomenclature of files from the CASU processing please see page 5.

```
r.HAWKI.<DP_ID>_til_<NN>.png
```

where <DP_ID> is the time stamp of the first exposure and <NN> is a running number from 0 to 4: <NN>=0 is the preview for the tile while <NN>=1, 2, 3, and 4 are the previews for the respective extensions of the jittered product.

# Acknowledgements