ESO Science Archive Facility - Phase 3 Data Release Description
ESO public survey programme VISIONS - VISTA Star Formation Atlas, Data Release DR1
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VISIONS - VISTA Star Formation Atlas
Data Release 1

Programme ID: 198.C-2009
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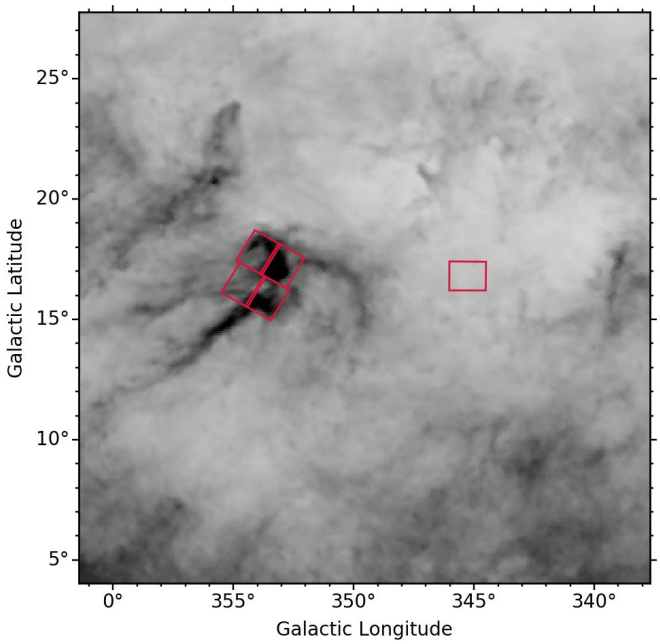
Abstract

VISIONS is a sub-arcsec near-infrared atlas of all nearby (d < 500 pc) star formation complexes accessible from the southern hemisphere. The atlas will contain tens of thousands of young stars (from 0.1 to 10 Myr), will be sensitive to objects down to a few Jupiter masses, and reach spatial resolutions of 100-250 AU in the nearby star-forming regions. Here we present VISIONS DR1, the first VISIONS data release. VISIONS DR1 contains the dense regions of the nearby Ophiuchus star-forming region (the *deep* data) and a control field (the *control* data) and gives a first flavor of what to expect from the final VISIONS survey data products. The quality of the imaging data is excellent (median FWHMs of 0.84'', 0.68'', and 0.66'' in J, H, and Ks, respectively).

Overview of Observations

The VISIONS ESO public survey consists of three distinct sub-surveys: *Deep*, *Control*, and *Wide* field observation (the reader is referred to the survey management plan or the VISIONS proposal for a detailed description and purpose of these sub-surveys). This release contains only data from the *deep* and *control* field surveys in the J, H, and Ks NIR passbands and specifically only data associated with the Ophiuchus star-forming region.



The figure to the right shows the sky coverage for VISIONS DR1, where the red boxes are individual tiles and, specifically, the box at l ~ 345° is the *control* field. The total sky coverage across all fields is about 7.5

square degrees. This number does not include the sky offset pawprints, which are not included in this data release.

Release Content

As stated in the survey management plan, VISIONS DR1 contains all available data products of the *deep* and *control* observations that were observed by April 2018. This includes reduced files for the Ophiuchus *deep* and *control* fields in the NIR passbands J, H, and Ks. However, two OB sequences in J band were not fully executed and only re-observed later than April 2018. These re-observed sequences are also included in this release to offer the community access to all data products associated with the *deep* and *control* sub-surveys for Ophiuchus.

Data

Excluding the faulty J-band sequences (and including the re-observed tiles), VISIONS DR1 contains a total of 1710 files. This includes:

- 108 *control* pawprints + their associated weights and source catalogs (324 files)
- 432 *deep* pawprints + their associated weights and source catalogs (1296 files)
- 27 tiles + their associated weights and source catalogs (81 files)
- 9 band-merged source catalogs for individual tiles. The band-merged catalogs are not aperture-matched and are released as associated products to the tile catalogs.

The pawprints consist of

- 1 *control* field tile in each observed band (J/H/K) with every 36 pawprints (NJITTER=6), therefore 108 pawprints.
- 8 Ophiuchus tiles (4 individual tile pointings) in each observed band. Each sequence consists of 18 pawprints, which totals to 432 pawprints (8 tiles x 18 pawprints x 3 bands). Each Ophiuchus *deep* sequence also featured 9 sky offset pawprints for improved background subtraction which are not included in this release.

The tiles consist of

- 1 tile per observed band for the *control* field
- 8 tiles for each band for the Ophiuchus *deep* field.

Source Counts and Data Volume

The total number of all source detections across all pawprints and all detectors is 24,796,641 (which includes duplicates and spurious detections). For the 540 pawprints we, therefore, have about 46,000 per pawprint and about 2,900 on average at the detector level. The total number of detected sources across all 27 tiles is 6,358,189.
The data volume for the 540 individual pawprints is 135.33 GB. Their associated weightmaps total to 135.31 GB (less than the actual imaging products due to less information in the FITS headers). The data volume for the source tables at the pawprint level is 3.73 GB.
For the 27 individual tiles, there are 36.07 GB data for the tiles and another 36.07 GB for the associated weightmaps. The source tables for the tiles amount to 0.85 GB. An additional 1.01 GB of data were submitted in the form of band-merged source catalogs.

Release Notes

Data reduction and Calibration

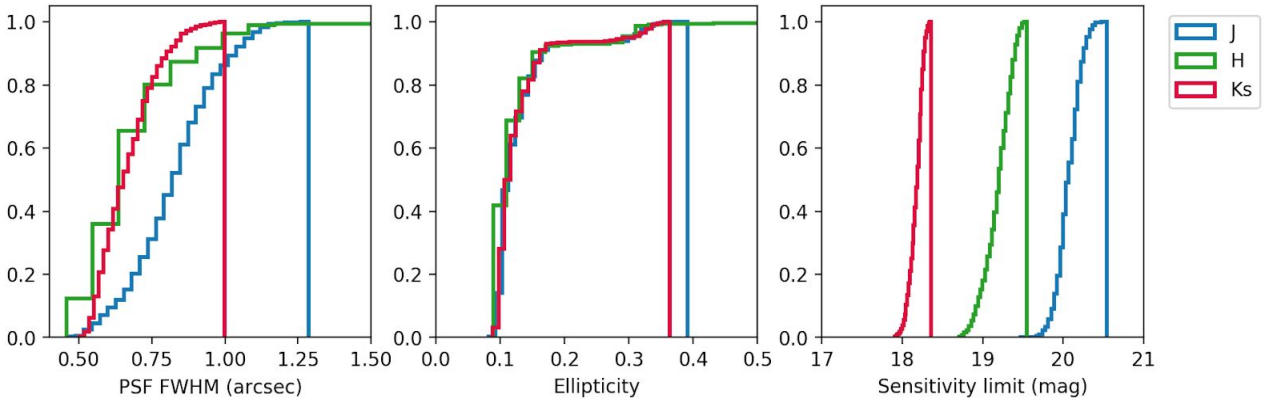
Data reduction followed standard procedures by removing the dark current, flat fielding the data and applying a gain harmonization across individual detectors. Astrometric calibration, flux scaling, and coaddition were carried out with Scamp and SWarp. Source detection and extraction were done with SExtractor in all cases with a 1.5-sigma detection threshold above the local background after convolution with 2.5 pix Gaussian kernel.

For the astrometric calibration, the Gaia DR2 database (epoch 2015.5) was used. The photometric calibration was carried out by cross-matching detected sources to 2MASS and deriving zero-points by comparing measured source counts with 2MASS photometry. For the J, H, and Ks bands, we used ranges of [12, 15], [11.5, 14.5], and [11, 14] mag, respectively. Seeing variations were handled by scaling images at the detector level by zero-point differences across pawprints. Remaining systematic errors are mitigated by the fact that seeing conditions were generally excellent across all observations for this release. Furthermore, no correction in extinction has been applied to the data.

Data Quality

Data processing from the raw ESO archive imaging products of the survey to the final source catalogs is done in the framework of a dedicated pipeline software, operated at the University of Bordeaux and the University of Vienna. Quality control consists of visual inspection of a series of plots and also visual inspection of color-magnitude diagrams resulting from the data reduction procedure.

Here, we briefly summarize the most important image quality aspects for VISIONS DR1 by discussing a series of plots generated from such quality control parameters as determined in our data reduction.

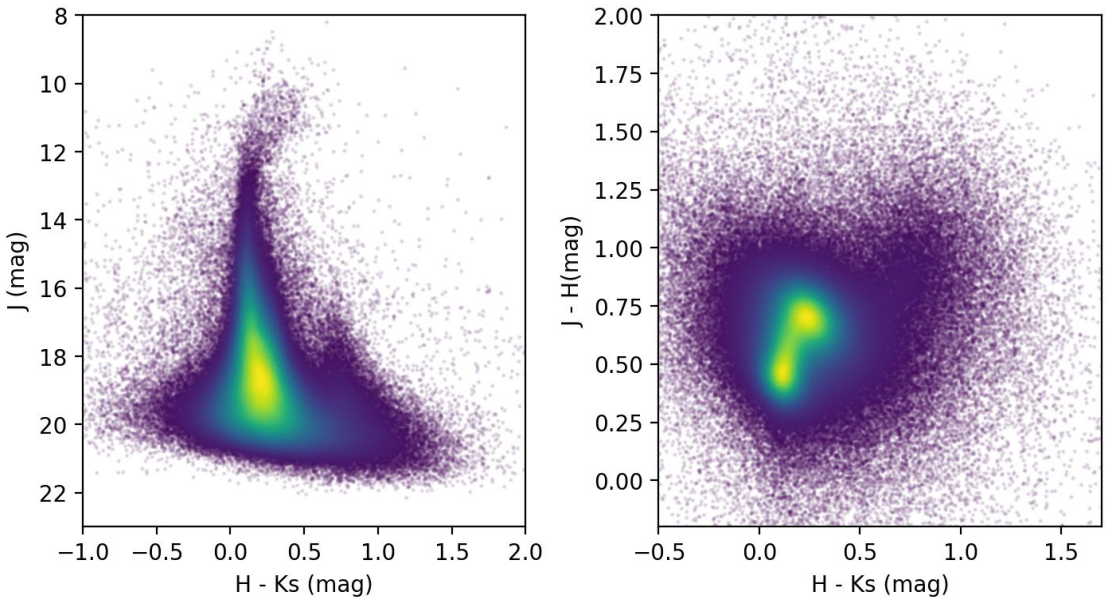


The figure above shows cumulative histograms for the full width half maximum (FWHM), ellipticity, and sensitivity limit across all pawprints included in VISIONS DR1. Here, the colors indicate different passbands (blue: J; green: H, red: Ks).

The overall image quality is excellent, with median FWHMs of 0.84'', 0.68'', and 0.66'' in J, H, and Ks, respectively. As a consequence, about half of all point sources are undersampled in H and Ks, given a pixel scale of about 0.33''/pix on VIRCAM.

Median 5-sigma limiting magnitudes for J, H, and Ks are 20.1, 19.2, 18.2 mag. We note here, that this is below the stated survey goals because these statistics refer to the pawprint level. In addition, each Ophiuchus *deep* tile has been split into two separate OB sequences, resulting in two separate tiles for each individual pointing. Therefore, the final numbers on the sensitivity limit are not available yet and will be published at a later stage.

The following image shows the color-magnitude (left) and the color-color (right) diagrams for the Ophiuchus *control* field constructed with sources that have a Sextractor FLAG < 8. The color-magnitude diagram clearly shows a bend in the main sequence at about J~12 mag which is due to residual non-linearity and saturation issues. The color-color diagram to the right clearly shows a well-defined main-sequence and, as expected, a relatively poorly populated galaxy locus (H-Ks ~ 1 mag, J-H ~ 1 mag).



Astrometry

A precise astrometric calibration was computed using Scamp with the Gaia DR2 catalog as an external reference. The absolute astrometric accuracy is set by Gaia DR2. Non-linear geometric distortions were fitted using a third order polynomial. The internal accuracy is estimated to be better than 30mas in all cases.

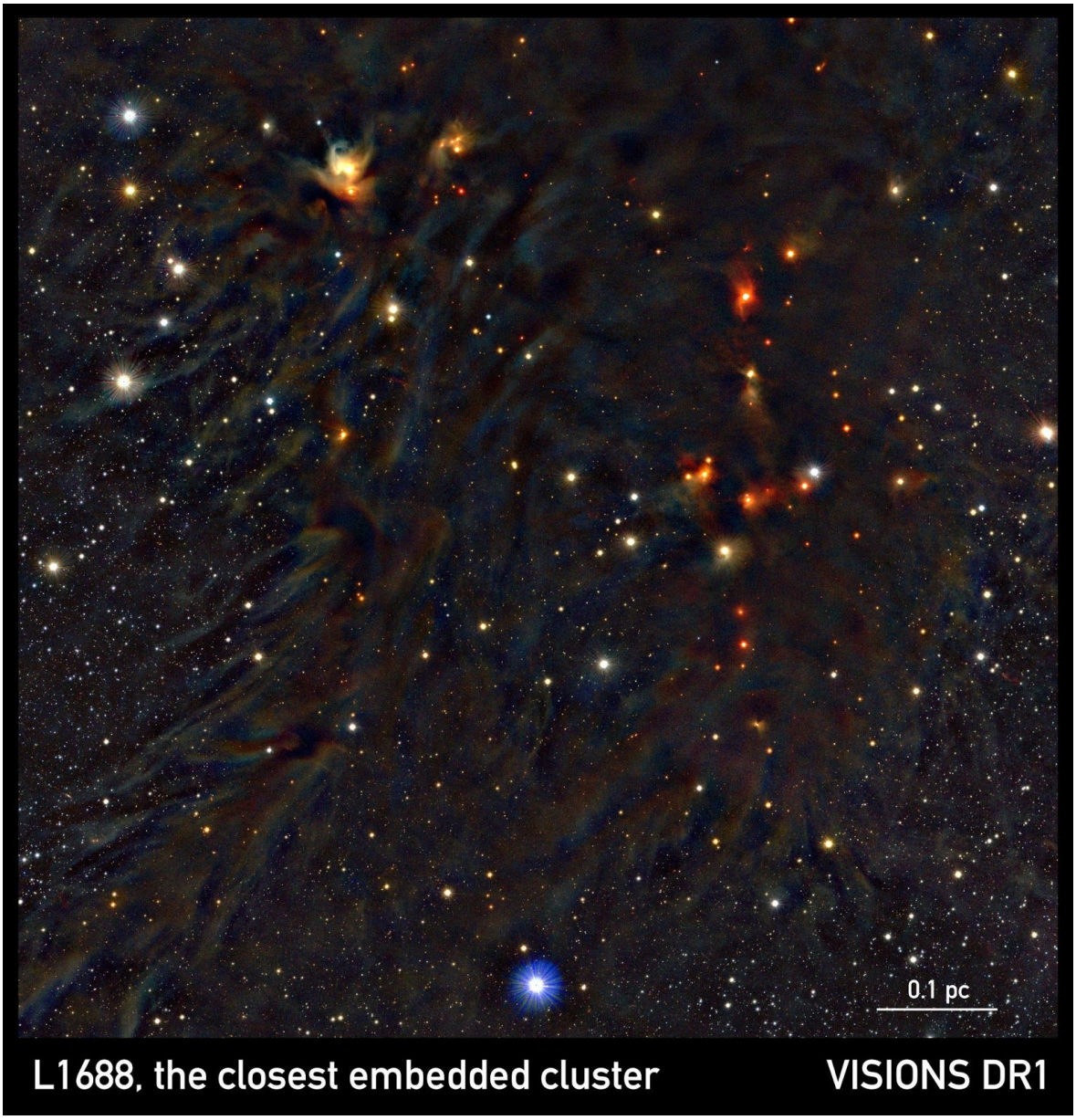
Known issues

Sources brighter than the 1.5σ noise of the local background in the filtered images (convolved by a 2.5 pixel Gaussian) were detected and their photometry and position measured using SExtractor. The weightmaps were used to properly modulate the detection threshold over the image.

Such a relatively low extraction threshold implies that the catalogs contain a significant number of spurious detections. As a consequence, we highly recommend making use of the SExtractor FLAGS provided with the catalogs to filter out such potentially spurious detections. Users are invited to refer to SExtractor documentation for a description of the FLAGS.

Previous Releases

This is the first data release for the ESO public survey VISIONS. No reduced data has been released previously.



RGB composite (lower resolution) made from VISIONS DR1 data, covering about 625 arcmin^2 in the sky towards L1688, the nearest embedded stellar cluster to Earth. Several disk-like objects can be seen in the scattered light, as well as the complex structure of YSO envelopes, seen here at the resolution of about 100 AU. The data, as all VISIONS data, were taken on the Galactic frame.

Data Format

File types

Both image and catalog files in this release are in FITS format. The imaging and catalog data for the pawprints preserves the 16 FITS extensions, each associated with a detector of VIRCAM. Imaging data products for tiles only contain a primary header-data-unit, whereas the associated FITS tables store the source list in the first FITS extension of the file.

Each tile or pawprint catalog contains a source list with a total of 28 columns:

- X/Y image coordinates in the associated pawprint/tile
- Right ascension and Declination of the source
- 8 differently measured magnitudes and their associated errors (5 fixed apertures of 2,3,4,5 and 6" diameter, Petrosian, isophotal, and Kron aperture photometry). For the Petrosian and the Kron-like aperture photometry, also the used aperture radii are included. In total, there are 18 parameters associated with source photometry.
- Ellipticity, Elongation, and FWHM as measured by Sextractor
- Sextractor star/galaxy classifier and FLAGS parameter
- DR1 source ID constructed from the source coordinates

In addition to the catalogs extracted from the individual imaging products, we also supply band-merged catalogs on a tile-basis. Here, the cross-match between different bands has been performed with a nearest-neighbor search with a maximum distance of 1-arcsec. These band-merged catalogs contain a total of 80 columns, where the WCS coordinates for all sources have been averaged across the bands without weighting. The band-merged catalogs are not aperture-matched and are released as ancillary products to the single band source lists. Therefore, they can be downloaded only together with them.

All filenames across DR1 were constructed in a homogeneous approach. The names altogether start with "VISIONS_*target_survey_band*". Specifically for DR1, *target* exclusively equals "Ophiuchus", *survey* is either "deep" or "control", and *band* equals the filter of the associated data product (J, H, or K).
For the pawprints, the filename then includes the pointing ID as returned by the Survey area definition tool (SADT) and a running sequence number[1]. The running sequence number before the file ending sorts all data by observing time but includes sky offsets. As a consequence, this number reaches up to 24 for the *deep* pawprints and omits those numbers that are related to the sky offsets. Tiles follow the same naming convention, they omit, however, the running sequence number and instead include "tl" at this point.

[1] The *control* field does not include the pointing ID, because it consists of only a single tile.

The file ending is exclusively ".fits", where source catalogs end with ".cat.fits" and weightmaps with ".weight.fits". Thus, the name of each source catalog compared to the related imaging product differs only in the additional ".cat" before the file name ending.

Catalog Columns

The following list contains a description of each table column

X_IMAGE	X pixel coordinate of source
Y_IMAGE	Y pixel coordinate of source
RA	Right Ascension of source (J2000) (deg)
DEC	Declination of source (J2000) (deg)
MAG_APER1	Source magnitude; fixed aperture photometry (r = 1") (mag)
MAGERR_APER1	Error of fixed aperture source magnitude (mag)
MAG_APER2	Source magnitude; fixed aperture photometry (r =1.5") (mag)
MAGERR_APER2	Error of fixed aperture source magnitude (mag)
MAG_APER3	Source magnitude; fixed aperture photometry (r =2") (mag)
MAGERR_APER4	Error of fixed aperture source magnitude (mag)
MAG_APER4	Source magnitude; fixed aperture photometry (r =2.5") (mag)
MAGERR_APER4	Error of fixed aperture source magnitude (mag)
MAG_APER5	Source magnitude; fixed aperture photometry (r =3") (mag)
MAGERR_APER5	Error of fixed aperture source magnitude (mag)
MAG_ISO	Source magnitude in isophotal contour (mag)
MAGERR_ISO	Error of isophotal magnitude (mag)
MAG_PETRO	Source magnitude for Petrosian aperture (mag)
MAGERR_PETRO	Error of Petrosian magnitude (mag)
MAG_AUTO	Source magnitude for Kron-like aperture (mag)
MAGERR_AUTO	Error of Kron-like magnitude (mag)
KRON_RADIUS	Radius used for Kron-like aperture (pix)

PETRO_RADIUS	Radius used for Petrosian aperture (pix)
CLASS_SEX	Sextractor star/galaxy classifier [0,1]
ELLIPTICITY	Source ellipticity
ELONGATION	Source elongation
FWHM	Full width half maximum (arcsec)
ID	Source ID constructed from coordinates
FLAGS	Sextractor FLAG parameter

Acknowledgments

The VISIONS survey management team is currently working on a survey paper which will be published in 2019. Any publication making use of this data, whether obtained from the ESO archive or via third parties, must include the following acknowledgment:

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References

Automatic Astrometric and Photometric Calibration with SCAMP, E. Bertin, 2006, ADASS XV, Vol. 351, p.112
SExtractor: Software for source extraction, Bertin & Arnouts, 1996, A&AS, 117, 393
SWarp: Resampling and Co-adding FITS Images Together, Bertin, 2010, Astrophysics Source Code Library, ascl:1010.068.