UltraVISTA DR1 Catalogue Release

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1 Abstract

UltraVISTA is a ultra-deep near-infrared survey which targets a sub-area of the COSMOS field (Scoville et al. 2007). This document describes the matched source catalogue prepared for the first UltraVISTA DR1 catalogue release. To 5σ limit, our K_s-selected catalogue contains 216,268 sources observed in Y, J, H and K_s bands over the full UltraVISTA deep area (~ 1.8 deg^2), with NB118 observations covering the "ultra-deep stripes" area.

2 Overview of observations

The multi-wavelength catalogue table presented here is derived from the stacked images which have already been described the UltraVISTA DR1 survey paper (McCracken et al. 2012) and which have been distributed as part of the ESO UltraVISTA DR1 release[1]. The reader is referred to this paper for a complete description of the input image selection, data reductions, and stack quality assessments: an overview of the DR1 release is also given on the ESO DR1 page. A summary of the properties of the stacked images and their corresponding limiting magnitudes, taken from McCracken et al., is given in Table 1.

3 Release Content

Science products in this release comprise a single FITS table constructed by merging five independent catalogues created by running object detection software `SExtractor` (Bertin & Arnouts 1996) on each of the five UltraVISTA DR1 stacked images using a common detection image. For this release, the DR1 K_s stack is used as the detection image, with a detection threshold of 1.8σ and a minimum detection

[1] `http://www.eso.org/sci/observing/phase3/data_releases/ultravista_dr1.html`

Table 1: Characteristics of the stacks used to produce the catalogues (all magnitudes are in AB).

Filter	Typical exp. time per pixel	$5\sigma(2'')$ (±0.1 mag)	95% comp. (±0.1 mag)	seeing ($''$) (±0.1$''$)
Y	42360	24.6	24.2	0.82
J	49720	24.4	24.2	0.79
H	42520	23.9	24.1	0.76
K_s	39400	23.7	23.8	0.75
NB118	23773	22.9 ± 0.2	22.6	0.75

area of 5 connected pixels (note that our stacks are all resampled to the 0.15$''$/pixel). Version 2.13.2 of `SExtractor` was used to prepare these catalogues, which is available from the public SVN repository at astromatic.net[2].

Finally, a number of supplementary columns have been added to the FITS table; these are described in Section 5.2.

4 Release notes

4.1 Data reduction and calibration

Full details of the procedures used to produce the DR1 stacks, including input image selection, sky-subtraction and astrometric and photometric calibration is given in McCracken et al.. For the purposes of this catalogue release, we note that the astrometric calibration was carried out using a reference catalogue derived from the COSMOS field (Capak et al. 2007). Our absolute photometric calibration is based on the supplied CASU Vega-based calibration. Our photometric system is in AB magnitudes, and magnitudes are supplied in VISTA instrumental system. Note that CASU produces "flat" images which have constant flux per pixel for a uniform illumination; this is taken into account correctly during the image resampling stage (although the effect on our magnitudes is very small).

4.2 Data quality

In the DR1 survey paper we present comparisons to external photometric and astrometric catalogues; the catalogues used to make these comparisons are the same as those presented here and we now summarise some of these comparisons. Note first that the absolute astrometric calibration of COSMOS (which we use for our astrometric reference frame) is derived from VLA 20cm observations (Schinnerer et al. 2004), these positions are known to be offset slightly with respect to 2MASS (Capak et al. 2007). Our median offsets and 1σ RMS with respect to 2MASS is $(0.00, 0.14)$ arcsec and $(-0.07, 0.15)$ arcsec in RA and DEC respectively. To verify that our astrometric reference frame is consistent with COSMOS, we carried out a similar comparison with stars in the COSMOS ACS catalogue (Leauthaud et al. 2007). In RA and DEC, no offset is observed. The 1σ RMS in both directions for stars selected with $17.0 < K_s < 19.5$ is ~ 0.08 arcsec. The internal astrometric accuracy between different UltraVISTA bands is expected to be of this order or better, i.e., much better than one 0.15$''$ pixel.

[2] `http://www.astromatic.net/wsvn/public/`

We also compare the total magnitudes of stars in our catalogue (MAG_AUTO) with those in the 2MASS all-sky point source catalogue (Skrutskie et al. 2006). (Note also that 2MASS is used for the photometric calibration of the survey by CASU.) Of course, a significant limitation of this comparison is that the magnitude range over which sources in UltraVISTA and 2MASS overlap is relatively small. The running median is always within 0.05 magnitudes of zero for $15.0 < \mathrm{mag} < 17.0$. There is a slight systematic offset visible in H ($\sim$ 0.03) magnitudes; this could be due to incorrectly rescaling our exposures to slightly non-photometric images or a real offset between the two different photometric systems.

In our DR1 survey paper, more comparisons are presented with existing COSMOS photometric catalogues; these are not discussed here.

4.3 Known issues

As is evident in Table 1, the measured seeing is similar between the five UltraVISTA bands. However, notably in the K_s and H images, there is some variation *within* a given stack, due to seeing variation between the six individual pawprints, which manifests itself as north-south stripes of differing seeing, although the amplitude of these features are small ($0.1''-0.15''$ peak-to-peak, see Figure 9. in McCracken et al.). We are currently preparing PSF-homogenised version of these stacks and catalogues for a future release.

4.4 Previous releases

This release represents the first UltraVISTA "catalogue release". However, as already noted, these catalogues are based on imaging data products which have already been released by ESO as part of the UltraVISTA DR1 data release.

5 Data format

5.1 File types

Our merged catalogue is delivered as a standard FITS format table. It can be examined using any standard tool capable of reading FITS tables (e.g., `topcat` or `fv`). There are in total 331,077 sources in the catalogue corresponding to data volume of 67Mb.

5.2 Catalogue columns

A complete list of the catalogue columns is given in Table 2. A brief description of these columns now follows.

5.2.1 Source IDs (SOURCE_ID, NUMBER: 1,2)

For each object we construct a unique identifier, given in the SOURCE_ID column, following IAU convention[3], and comprising the release identifier ("UVISTADR1") and then the (truncated) RA, DEC of each object. NUMBER reports the running object ID.

5.2.2 Positional parameters (X_IMAGE, Y_IMAGE, ALPHA_J2000, DELTA_J2000: 3,4,5,6)

X_IMAGE and Y_IMAGE report the position of the object in pixels on the K_s stack (which applies to all the stacks, as they share identical co-ordinate systems). RA, DEC, based on the COSMOS astrometric reference frame, are reported in the ALPHA_J2000 and DELTA_J2000 columns.

5.2.3 Magnitude measurements and magnitude errors (_APER2, _APER7, _AUTO)

Aperture magnitudes are measured in 2″ and 7.1″ diameters respectively (_APER2 and _APER7 columns). Based on the average stellar profiles each of the four broad-band filters, these aperture magnitudes can be "corrected" to pseudo-total magnitudes by adding $\sim -0.35, -0.3, -0.2, -0.2$ magnitudes to the Y, J, H, K_s 2″ aperture magnitudes. These corrections are not applied to the catalogues delivered to the ESO archive. Total magnitudes, corresponding to SExtractor's MAG_AUTO output column in each of the five bands are also included (reported in the _AUTO columns for each band).

In all cases, magnitudes are reported in the AB system (Oke 1974) in the VISTA instrumental magnitude system. The conversion factor C from Vega to AB we use are as follows, in the sense $\mathrm{mag_{AB}} = \mathrm{mag_{vega}} + \mathrm{C}$ where $C = 0.61, 0.90, 1.38, 1.84, 0.86$ for Y, J, H, K_s and NB118 filters respectively. No attempt has been made to convert these magnitudes to a "standard" system.

SExtractor magnitude errors are reported for all quantities: it is known that these errors are underestimated for stacks with correlated noise, as is the case in UltraVISTA (Labbé et al. 2003). For Y, J, H and K_s 2″ aperture errors we have calculated multiplicative correction factors for each band of 2.5, 3.0, 2.1, and 2.5 based on comparing statistics of "empty apertures" with measured SExtractor aperture errors. As with the corrections to "total" magnitudes, application of these corrections are left to the catalogue user.

5.2.4 Object flags (_FLAG: 16,24,32,40,48)

For each band the SExtractor FLAG column is reported indicating if an object is blended or has otherwise corrupted photometric measurements. A bad region flag ("flag_hjmcc") is also supplied. Currently, this bad region flag only indicates objects (with a flag value of one) at the edge of the K_s detection image; bright stars are not flagged in this catalogue version. To select objects with non-corrupted photometry for the NB118 data, one should select in addition only objects with NB118_FLAG < 1. Note that away from very bright objects, due to the very high quality of the final stacked frames and the relatively conservative detection threshold adopted, the number of spurious sources in the catalogues above the five-sigma detection limits listed in Table 1 should be considered as essentially zero. In summary, the best possible object sample are those objects which have all FlAG columns equal to zero in all bands.

[3] http://cdsweb.u-strasbg.fr/Dic/iau-spec.html

5.2.5 Other columns: _FLUX_RADIUS, FLAG_HJMCC and EBV: 15,23,31,39,47, 7 and 8)

The radius which encloses 50% of the total object flux (computed using mag_auto) "flux_radius" is also reported in each band. By examining the distribution of objects in flux-radius and magnitude one can easily separate point-like and non point-like sources. Note that bright saturation limit for stellar sources in these catalogues is $\sim$ 14 magnitudes in Y and 15 magnitudes in JHK_s bands.

The galactic reddening $E(B-V)$ is reported at the co-ordinates of each object, computed using the Schlegel et al. (1998) dust maps. To convert the supplied reddening coefficient to (additive) extinction values appropriate for each Y, J, H, K_s filter this $E(B-V)$ value should be multiplied by 1.211, 0.871, 0.563 and 0.364, computed using a Cardelli et al. (1989) extinction law and the VISTA instrumental throughput.

FLAG_HJMCC is a masking flag which indicates the field boundaries: objects with a flag value of 1 are outside the field boundary.

6 Acknowledgements

Users of this catalogue should cite "McCracken et al. 2012 (Astronomy and Astrophysics, 544, A156)". The data source should be acknowledged as follows:

"Based on data products from observations made with ESO Telescopes at the La Silla Paranal Observatory under ESO programme ID 179.A-2005 and on data products produced by TERAPIX and the Cambridge Astronomy Survey Unit on behalf of the UltraVISTA consortium."

References

Bertin, E. & Arnouts, S. 1996, ApJS, 117, 393

Capak, P., Aussel, H., Ajiki, M., et al. 2007, ApJS, 172, 99

Cardelli, J. A., Clayton, G. C., & Mathis, J. S. 1989, ApJ, 345, 245

Labbé, I., Franx, M., Rudnick, G., et al. 2003, AJ, 125, 1107

Leauthaud, A., Massey, R., Kneib, J.-P., et al. 2007, ApJS, 172, 219

McCracken, H. J., Milvang-Jensen, B., Dunlop, J., et al. 2012, A&A, 544, A156

Oke, J. B. 1974, ApJS, 27, 21

Schinnerer, E., Carilli, C. L., Scoville, N. Z., et al. 2004, AJ, 128, 1974

Schlegel, D. J., Finkbeiner, D. P., & Davis, M. 1998, ApJ, 500, 525

Scoville, N., Aussel, H., Brusa, M., et al. 2007, ApJS, 172, 1

Skrutskie, M. F., Cutri, R. M., Stiening, R., et al. 2006, AJ, 131, 1163

Table 2: Complete list of supplied catalogue columns.

Column Number	Column name	Description
1	SOURCE_ID*[1]	UltraVISTA source designation (DR1)
2	NUMBER*	Running object number
3	ALPHA_J2000*	Right ascension of barycenter in decimal degrees (J2000)
4	DELTA_J2000*	Declination of barycenter in decimal degrees (J2000)
5	X_IMAGE*	Object position along x
6	Y_IMAGE*	Object position along y
7	FLAG_HJMCC*	Bad region flag: != 0 for bad region (field boundaries: 1)
8	EBV*	Galactic reddening E(B-V) based on Schlegel et al (1998) dust maps
9	Y_APER2*	Y fixed aperture magnitude (2",AB)
10	Y_APER2_ERR*	Y fixed aperture mag error (2",AB)
11	Y_APER7*	Y fixed aperture magnitude (7",AB)
12	Y_APER7_ERR*	Y fixed aperture mag error (7",AB)
13	Y_AUTO*	Y auto magnitude (AB)
14	Y_AUTO_ERR*	Y auto mag error (AB)
15	Y_FLUX_RADIUS*	Radius of aperture containing half the flux of Y_MAG_AUTO
16	Y_FLAG*	Y Flag (sextractor)
17	J_APER2*	J fixed aperture magnitude (2",AB)
18	J_APER2_ERR*	J fixed aperture mag error (2",AB)
19	J_APER7*	J fixed aperture magnitude (7",AB)
20	J_APER7_ERR*	J fixed aperture mag error (7",AB)
21	J_AUTO*	J auto magnitude (AB)
22	J_AUTO_ERR*	J auto mag error (AB)
23	J_FLUX_RADIUS*	Radius of aperture containing half the flux of J_MAG_AUTO
24	J_FLAG*	J Flag (sextractor)
25	H_APER2*	H fixed aperture magnitude (2",AB)
26	H_APER2_ERR*	H fixed aperture mag error (2",AB)
27	H_APER7*	H fixed aperture magnitude (7",AB)
28	H_APER7_ERR*	H fixed aperture mag error (7",AB)
29	H_AUTO*	H auto magnitude (AB)
30	H_AUTO_ERR*	H auto mag error (AB)
31	H_FLUX_RADIUS*	Radius of aperture containing half the flux of H_MAG_AUTO
32	H_FLAG*	H Flag (sextractor)
33	KS_APER2*	Ks fixed aperture magnitude (2",AB) [detection image]
34	KS_APER2_ERR*	Ks fixed aperture mag error (2",AB) [detection image]
35	KS_APER7*	Ks fixed aperture magnitude (7",AB) [detection image]
36	KS_APER7_ERR*	Ks fixed aperture mag error (7",AB) [detection image]
37	KS_AUTO*	Ks auto magnitude (AB) [detection image]
38	KS_AUTO_ERR*	Ks auto mag error (AB) [detection image]
39	KS_FLUX_RADIUS*	Radius of aperture containing half the flux of KS_MAG_AUTO
40	KS_FLAG*	Ks Flag (sextractor) [detection image]
41	NB118_APER2*	NB118 fixed aperture magnitude (2",AB)
42	NB118_APER2_ERR*	NB118 fixed aperture mag error (2",AB)
43	NB118_APER7*	NB118 fixed aperture magnitude (7",AB)
44	NB118_APER7_ERR*	NB118 fixed aperture mag error (7",AB)
45	NB118_AUTO*	NB118 auto magnitude (AB)
46	NB118_AUTO_ERR*	NB118 auto mag error (AB)
47	NB118_FLUX_RADIUS*	Radius of aperture containing half the flux of NB118_MAG_AUTO
48	NB118_FLAG*	NB118 Flag (sextractor)

[1] A "*" after the column name means that the FITS header keyword TINDXi for that column has been set to T