ESO observing programme GCAV: Galaxy Clusters At Vircam (198.A-2008 PI. M. Nonino)

Abstract

We release coadded tiles and related source lists form data collected within the ESO Public Survey GCAV (198.A-2008). Data have been obtained with VISTA/VIRCAM in Y,J, and Ks bands. GCAV targeted 20 massive galaxy clusters which have been observed in many ground based and spaced based programs (e.g. CLASH, RELICS, HFF/BUFFALO). This is the third data release (DR3), and contains all the 525 OBs collected in the survey with ESO grade A and B.
Stacks and source lists of OBs released in DR1 (224 files) and DR2 (616 files) are replaced in DR3.
Full stack images and catalogues will be part of a future release. The total area covered by the observations is ~38deg^2. The volume of the released data, images and catalogues, is ~2.3 Tb

Overview of Observations

Observations for the ESO Programme 198.A-2008 have been carried out in Obs 63.25 min long in Y and J, and 61.25 min long in Ks. The pattern is the Tile6n with on sky exposures of 48 min in Y and J, and 42 min in Ks. For each Y and J exposure , DIT is set to 30s., NDIT to 2 and NJITTER to 8; for Ks exposures DIT is 10s., NDIT is 6, and NJITTER is 7.

The 20 galaxy clusters are:

Abell 370, Abell 1300, Abell 2163, Abell 2744, ACT-CLJ0102-49151, EMMS0451-0306, MACSJ0416.1-2403, MACSJ0553.4-3342, PLCKG004.5-19.15, PLCKG287.0+32.9, RCS2J2327.6-020437, RXCJ0600.1-2007, RXCJ1347.5-1145, RXCJ1514.9-1523, RXCJ2129.6-0005, RXCJ2211.7-0350, RXCJ2248.7-4431, SMACSJ0723.3-7327, SPT-CLJ0254-5857, WHLJ243324-8.477.

Release Content

TABLE 1. Summary of the released images and source lists per cluster at OB level:

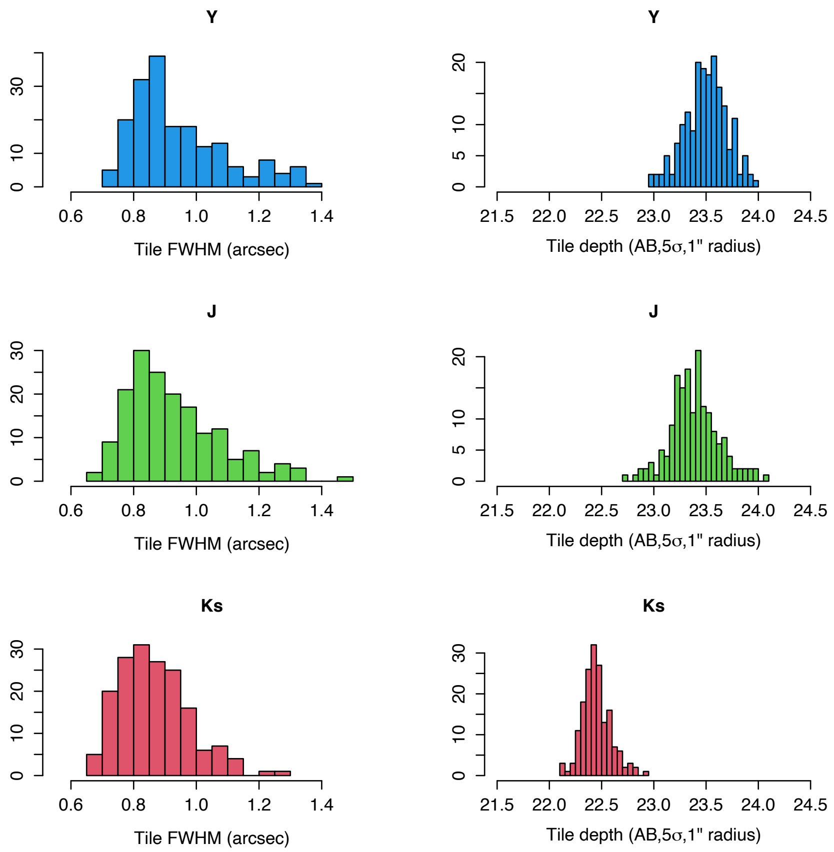
Cluster FieldID	RJ2000 DECJ2000	Filter	N. OBs	Total exptime (sec.)	Eptime per pixel (sec.)	Psf FWHM,min:max, arcsec	MagLim(AB),min:max	Size images+weights+source lists (Gb)
Abell 370	02:40:00 -01:35:00.0	Y	8	22500	7500	0.80:1.21	23.64-23.97	34.885
		J	10	25980	8660	0.71:1.30	23.15-23.89	43.612
		Ks	10	25200	8400	0.78:1.01	22.45-22.91	43.582

Abell 1300	11:32:20.0 -19:45:00.0	Y	8	23040	7680	0.79:1.20	23.19-23.60	33.006
		J	7	20100	6700	0.79:1.28	23.10-23.67	30.675
		Ks	5	12600	4200	0.66:0.90	22.32-22.56	21.794
Abell 2163	16:15:50 -06:09:10.0	Y	7	20160	6720	0.72:1.28	23.32-23.85	31.186
		J	7	20160	6720	0.87:1.07	23.19-23.53	31.179
		Ks	8	20160	6720	0.75:0.97	22.45-22.71	35.604
Abell 2744	00:14:15.0 -30:35:30.0	Y	10	28800	9600	0.74:1.30	23.03-23.79	44.631
		J	8	23040	7680	0.73:1.13	23.21-23.66	33.762
		Ks	10	24840	8220	0.70:1.11	22.30-22.56	44.438
ACT-CLJ 0102-49151	01:04:30.0 -49:09:30.0	Y	9	24960	8320	0.76:1.07	23.21-23.58	39.764
		J	9	25740	8580	0.86:1.17	22.87-23.79	39.744
		Ks	11	27720	9240	0.78:1.07	22.26-22.63	48.382
EMM-S0451-0306	04:54:17.0 -03:00:15.0	Y	10	28620	9540	0.83:1.28	23.31-23.86	44.883
		J	8	22860	7620	0.82:1.07	23.26-23.61	35.906
		Ks	10	24240	8080	0.78:1.08	22.33-22.73	44.855
MACSJ 0416.1-2403	04:16:30.0 -24:02:30.0	Y	10	28800	9600	0.81:1.21	23.25-23.57	44.615
		J	8	23040	7680	0.75:1.17	23.09-23.53	35.698
		Ks	10	25200	8400	0.72:1.10	22.30-22.49	44.598
MACSJ 0553.4-3342	05:53:55.0 -33:35:00.0	Y	8	22500	7500	0.79:1.22	23.12-23.78	35.933
		J	10	28800	9600	0.68:0.91	23.22-23.71	44.952
		Ks	10	24660	8220	0.76:1.06	22.28-22.58	44.909
PLCK-G004.5-19.15	19:18:00.0 -33:25:30.0	Y	12	34560	11520	0.83:1.24	22.96-23.57	54.569
		J	12	34500	11500	0.77:1.01	23.06-23.44	54.592
		Ks	11	27720	9240	0.70:0.85	22.33-22.50	49.775
PLCGK287.0+32.9	11:51:00.0 -28:10:00.0	Y	10	28800	9600	0.77:1.05	23.26-23.72	44.508

		J	8	23040	7680	0.78:1.23	23.22-23.54	35.617
		Ks	7	17640	5880	0.72:1.11	22.20-22.47	31.131
RCS2J 2327.6-020437	23:27:00.0 -02:02:15.0	Y	13	37440	12480	0.76:1.33	23.00-23.61	57.526
		J	12	34560	11520	0.78:1.24	22.92-23.55	53.143
		Ks	11	27720	9240	0.70:1.21	22.15-22.50	48.629
RXCJ 0600.1-2007	06:00:35.0 -19:59:45.0	Y	10	28380	9460	0.79:1.33	22.99-23.64	44.366
		J	8	22980	7660	0.76:1.18	23.17-23.53	35.500
		Ks	7	17640	5880	0.75:0.93	22.30-22.69	31.021
RXCJ 1347.5-1145	13:47:30.0 -11:45:10.0	Y	10	28800	9600	0.78:1.35	23.10-23.80	44.047
		J	8	23040	7680	0.78:1.34	23.27-23.73	35.246
		Ks	8	20160	6720	0.68:1.08	22.44-22.69	35.230
RXC J1514.9-1523	15:15:00.0 -15:21:25.0	Y	8	23040	7680	0.80:1.33	23.12-23.71	35.341
		J	7	20160	6720	0.80:1.16	22.97-23.64	30.960
		Ks	5	12900	4300	0.70:0.95	22.52-22.63	22.104
RXCJ 2129.6+0005	21:29:45.0 00:05:00.0	Y	7	20160	6720	0.78:1.08	23.22-23.68	31.414
		J	6	17280	5760	0.91:1.06	23.08-23.43	26.923
		Ks	5	12600	4200	0.72:0.96	22.32-22.50	22.424
RXCJ 2211.7-0350	22:12:30.0 -03:45:00.0	Y	10	28800	9600	0.77-0.95	23.33-23.93	43.963
		J	8	23040	7680	0.68:1.11	23.22-23.57	35.176
		Ks	7	17640	5880	0.67:0.93	22.35-22.40	30.760
RXCJ 2248.7-4431	22:49:30.0 -44:22:30.0	Y	10	28800	9600	0.74:1.1	23.29-23.86	44.529
		J	8	23040	7680	0.70:1.28	22.92-24.00	35.642
		Ks	10	25200	8400	0.71:1.08	22.13-22.53	44.496
SMACSJ 0723.3-7327	07:25:00.0 -73:20:00.0	Y	8	23040	7680	0.86:1.18	23.26-23.57	35.326
		J	8	23040	7680	0.76:1.47	22.74-23.60	35.330

		Ks	8	20160	6720	0.87:1.27	22.14-22.49	35.298
SPT-CLJ 0254-5857	02:55:40.0 -58:50:00.0	Y	8	23040	7680	0.73:1.30	23.35-23.78	35.641
		J	8	22140	7380	0.78:1.33	23.20-23.69	35.614
		Ks	9	22680	7560	0.78:1.02	22.33-22.83	40.049
WHLJ243324-8.477	01:37:10.0 -08:20:00.0	Y	9	25860	8620	0.86:1.14	23.41-23.86	39.709
		J	9	25560	8520	0.82:1.06	23.11-24.07	39.820
		Ks	9	22680	7560	0.80:0.94	22.25-22.49	40.520
							Total	2332.52

The limiting mag is 5σ within 1" radius aperture and includes aperture correction to 5" aperture radius: MagLim = ZP -2.5*log10(5*sqrt(pi*25)*skyrms) – APCORR1



The plots show the distribution of the estimated FWHM and 5σ depth of the released tiles.

Release Notes

Data Reduction and Calibration

- Data reduction has been performed with a pipeline written in Julia (www.julialang.org) which develops e.g. Nonino et al. 2009 , and performs the following steps:
- Linearity correction following http://casu.ast.cam.ac.uk/surveys-projects/vista/technical/data-processing/design.pdf/view
- Dark correction, subtracting the associated dark image, created from median combination of nightly darks, and matching the DIT value of the given science exposures.
- De-striping, which removes the low-level horizontal striping due to VIRCAM detector readout electronic.
- Flat field correction, dividing by a median of twilight sky images also compensating for different gain in the different detectors.
- Creation of statics masks which flag pixels with substantial deviates in the dark and flat calibration images. These pixels are assigned weight 0.
- Astrometric solution is performed against GAIA EDR3 sources (https://gea.esac.esa.int/archive), using Scamp (v2.0.4,Bertin 2006) Using GAIA proper motion information, reference sources coordinates have been corrected to the epoch of VIRCAM observations. The systematics in the coadded images are at the level of 10 mas and less, and rms ~20 mas with respect to GAIA sources. The density of used GAIA sources per VIRCAM ranges from ~100 to 500 depending upon the cluster.
- Photometry: the zero point of each coadded tile has been derived from comparison of aperture corrected magnitudes of bright but unsaturated sources with the aperture corrected magnitude from the source lists delivered by the VISTA Data Flow System (Irwin et al. 2004, Hambly et al. 2008, Cross et al., 2012). This has also been used to apply a final illumination correction (at the level of the stack). For a very detailed analysis of the VISTA photometric system, including Vega to AB conversion, we refer to Gonzales-Fernandez et al. (2018, MNRAS,474). The comparison of bright unsaturated sources results in a median and mean rms of 0.037 indicative of the limits of photometric systematics of the released data. Further comparisons of aperture corrected magnitudes against VIKING, VHS observations partly overlapping released clusters confirm this result. Further check on the photometric calibration has been performed stacking chip by chip each OB. This resulted in 96 stacks for each OB, for which PSF has been estimated, using PSFex (v.3.21.1, Bertin, 2011): photometry of bright, not saturated stars has been compared with 2MASS sources, confirming the obtained zero points (RMS <0.05) in the AB interval ~13.5-16.
- Background subtraction: this step is performed using the astrometric solutions to mask each pixel, in the dark and flat corrected images, which in the coadded stack has been mapped into a detected object. Defect such as satellite tracks have been masked with the mask incorporated in the single image weight map.
- Tile and deep stacks are obtained using a slightly modified version of Swarp (v2.19.1, Bertin et al. 2002).
- Psf obtained via PSFex (v3.2.11,Bertin, 2011).

Released source lists have been obtained using Sextractor (v2.19.5, Bertin & Arnouts 1996). Purity has been preferred to completeness, in order to minimize spurious detections. Running Sextractor on the inverted images (additive inverse) result in a fraction of < .001 of spurious sources, due to noise in the image background, see also Know Issues below, for the selected parameters. Relevant parameters:

```
DETECT_MINAREA 9
DETECT_THRESH 4
THRESH_TYPE RELATIVE
FILTER Y
FILTER_NAME gauss_1.5_3x3.conv
DEBLEND_NTHRESH 32
DEBLEND_MINCONT 0.00005
```

CLEAN Y
CLEAN_PARAM 1
MASK_TYPE CORRECT
PHOT_AUTOPARAMS 2.5,3.5
BACK_SIZE 256
BACK_FILTERSIZE 2
BACKPHOTO_TYPE LOCAL
BACKPHOTO_THICK 24

Data Quality

- The astrometry has been performed using GAIA3 as reference: systematics and random errors are listed in the header of the images CSYER1, CSYER2, CRDER1, CRDER2 (units degrees).
- Adopted conversions to AB (Gonzales-Fernandez et al. 2018, D3, D4 and D6): Y_AB(+0.600), J_AB(+0.916), Ks_AB(+1.827)
- Magnitudes from aperture radii of 1”,1”.5,2”,2”.5,3”,4” and PSFMag have been corrected to aperture radius 5”, for each stacked tile. Magnitudes have **NOT** been corrected for Galactic extinction.
- The zeropoints are uniform across each tile.

Known issues

Varying quantum efficiency in detector 16 result in problematic regions in the coadded images as can be seen in the 5 sigma depth figure (top left region). In the current release, the most common source of spurious objects in source lists is associated with diffraction halos and filter-reflection ghosts around bright stars; these are easily recognized in the parent images since they are mostly localized around bright stars.

Previous Releases

This Release replaces DR1 and DR2, with new astrometric reference system (GAIA-EDR3)

Data Format

Files Types

The naming convention for the released data is
science image
gcav_$CLUSTER_NAME$_$FILTER$_$OBID$_g3sw.fits
associated weight image
gcav_$CLUSTER_NAME$_$FILTER$_$OBID$_g3sw.weight.fits
associated source source list
gcav_$CLUSTER_NAME$_$FILTER$_$OBID$_g3sw_cat.fits

Catalogue Columns

No	Column Name	Column Description
1	SOURCENAME	IAU-formatted name, prefixed with “GCAV”

2	SOURCEID	Running object number
3	RA2000	Right ascension of barycenter (J2000)
4	DEC2000	Declination of barycenter (J2000)
5	MAG_AUTO	Kron-like elliptical aperture magnitude
6	MAGERR_AUTO	RMS error for Kron-like elliptical aperture magnitude
7	KRON_RADIUS	Kron aperture
8	MAG_ISO	Isophotal magnitude
9	MAGERR_ISO	RMS error for isophotal magnitude
10	MAG_APER1	Aperture corrected magnitude within 1” radius
11	MAG_APER2	Aperture corrected magnitude within 1”.5 radius
12	MAG_APER3	Aperture corrected magnitude within 2” radius
13	MAG_APER4	Aperture corrected magnitude within 2”.5 radius
14	MAG_APER5	Aperture corrected magnitude within 3” radius
15	MAG_APER6	Aperture corrected magnitude within 4” radius
16	MAG_APER7	Aperture magnitude within 5” radius
17	MAG_APER8	Aperture magnitude within 7”.5 radius
18	MAG_APER9	Aperture magnitude within 10” radius
19	MAGERR_APER1	RMS error for aperture 1
20	MAGERR_APER2	RMS error for aperture 2
21	MAGERR_APER3	RMS error for aperture 3
22	MAGERR_APER4	RMS error for aperture 4
23	MAGERR_APER5	RMS error for aperture 5
24	MAGERR_APER6	RMS error for aperture 6
25	MAGERR_APER7	RMS error for aperture 7
26	MAGERR_APER8	RMS error for aperture 8
27	MAGERR_APER9	RMS error for aperture 9
28	FRAD90	Fraction-of-light radius at 90%
29	FLAGS	Sextractor flag
30	CLASS_STAR	Sextractor Star/Galaxy classification (0-galaxy,1-star)
31	FWHM_IMAGE	FWHM assuming a gaussian core (pixels)
32	BACKGROUND	Background at centroid position
33	A_IMAGE	Isophotal major axis
34	B_IMAGE	Isophotal minor axis
35	THETA_IMAGE	Isophotal image position angle

36	MAG_PSF	Magnitude from PSF-fitting
37	MAGERR_PSF	RMS error from PSF-fitting
38	MAG_MODEL	Magnitude from model-fitting
39	MAGERR_MODEL	RMS error for model-fitting magnitude
40	SPREAD_MODEL	Spread parameter from model-fitting
41	SPREADERR_MODEL	RMS error for spread parameter from model-fitting
42	MAG_POINTSOURCE	Point source total magnitude from fitting
43	MAGERR_POINTSOURCE	RMS error for fitted point source total magnitude
44	MAG_PETRO	Petrosian-like aperture magnitude
45	MAGERR_PETRO	RMS error for Petrosian-like aperture magnitude
46	PETRO_RADIUS	Petrosian radius

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