Data Collection	VMC
Release Number	3
Data Provider	Maria-Rosa Cioni
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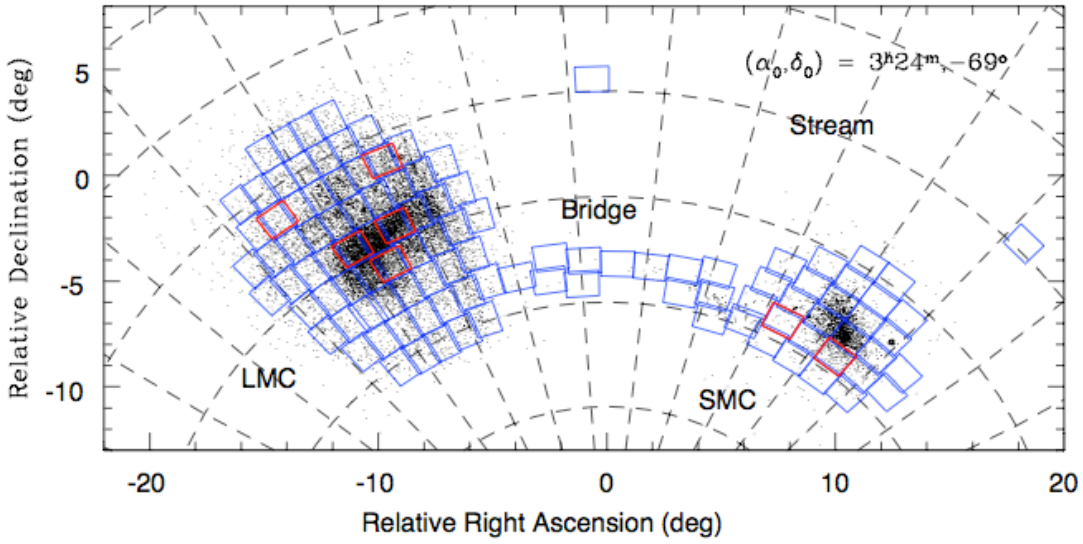
Abstract

Observations were obtained with the VISTA telescope as part of the VISTA survey of the Magellanic Cloud system (VMC; ESO program 179.B-2003) in three filters: Y, J and K_s. The main goals of the VMC survey are the determination of the spatially resolved star formation history and the three-dimensional geometry of the Magellanic system. The sensitivity of the data is designed to reach sources below the oldest main-sequence turn off point of the stellar population and the multi-epochs to measure accurate K_s mean magnitudes for pulsating variable stars, e.g. RR Lyrae stars and Cepheids.

This data release is based on the observations of five new VMC survey tiles LMC 5_5, 6_4, 8_3, and of tiles SMC 3_3, 3_5, as well as the re-reduced two tiles LMC 6_6 and 8_8. Observations were acquired between November 2009 and October 2012. This release provides 179 reduced and calibrated tile images belonging to individual observations ('single OBs'), in addition to the corresponding pawprints (6 per tile), and deep co-added images (separately for each filter). This release is superseding the previous release, meaning that all files of the previous VMC release number 2 are being replaced by new versions. There are at least three tiles in Y and J filters and twelve tiles in K_s filter per field. The total sky coverage of this release is ~7.5 deg^2 in the LMC and ~3 deg^2 in the SMC.



Overview of Observations

The figure above shows the Magellanic system as tiled by the VMC survey (blue) and tiles for which data are released (red). Underlying small dots indicate the distribution of carbon stars, stellar clusters and associations.

Tile numbering begins from the bottom right corner, increasing from right to left and from bottom to top. The first LMC tile is 2_3, the first SMC tile is 2_2, the first Bridge tile is 1_2 and Stream tile 1_1 is right above the Bridge while 2_1 is to the right of the SMC.

Each survey tile has at least 3 OBs in Y and J filters, respectively (providing 800 s exposure time per pixel each) and 12 OBs in K_s with 750 s exposure time per pixel each.

Release Content

This release covers five tiles in the Large Magellanic Cloud: LMC 5_5, 6_4, 6_6, 8_3 and 8_8, as well as two tiles in the Small Magellanic Cloud: SMC 3_3 and 3_5.

LMC tiles were oriented with the Y axis more or less along the declination direction while for SMC tiles the Y axis is along the right ascension direction. Each tile covers about 1.771 deg^2 where the central (1.475 x 1.017)=1.501 deg^2 corresponds to the nominal depth of the survey and the remaining area to half the exposure time in each band. Tile centres given in Right Ascension (RA), Declination (DEC) and the telescope position angle (TL_OFFAN) are listed below.

Tile	RA	DEC	TL_OFFAN
SMC 3_3	00:44:55.896	-74:12:42.120	-1.2120
SMC 3_5	01:27:30.816	-74:00:49.320	+8.9671
LMC 5_5	05:24:30.336	-70:48:34.200	-92.6525
LMC 6_4	05:12:55.800	-69:16:39.360	-95.3605
LMC 6_6	05:37:40.008	-69:22:18.120	-89.5708
LMC 8_3	05:04:53.952	-66:15:29.880	-97.2489
LMC 8_8	05:59:23.136	-66:20:28.680	-84.4802

Individual tile images and co-added tile images, with associated confidence maps and source lists, are released per band per field. Preview images in JPEG format are associated to each FITS image. They comprise observations obtained from November 2009 to October 2012 included.

This release is the first in the series of VMC data releases that includes the pawprint images based on individual observations (OBs) in addition to the corresponding tile images.

Data Quality

Source lists were created from images that were filtered for nebulosity with size of the order of 30 arcsec, but to the images released here the filtering process was not applied. See Irwin (2010, UKIRT Newsletter 26, 14).

The VMC constraints for the tiles in this release correspond to ellipticity <0.1 arcsec and seeing of 0.8-0.9 arcsec at K_s, 0.9-1.0 arcsec at J and 1.0-1.1 arcsec at Y, but good quality observations have a tolerance of ~10% on top of these values. The two values specified for seeing indicate constraints for crowded and uncrowded regions, respectively.

A few tiles outside VMC constraints are also released and their quality parameters are included in the headers, they refer to observations with higher seeing and/or ellipticity then those listed above. In total 23 tile images and their corresponding pawprints are affected. These refer to tiles: SMC 3_3 (8), SMC 3_5 (6), LMC 5_5 (2), LMC 6_4 (2), LMC 8_3 (1), and LMC 8_8 (4). Furthermore, some detectors are affected by intermittency and were discarded in the making of pawprints and tiles. This occurs, for example, in tile LMC 6_4 in K_s. Note that the sensitivity of tile images is by construction higher than that of pawprint images.

The average data quality per individual tile, observed within VMC constraints, is as follows.

Tile	Filter	EXPTIME (s)	SEEING (arcsec)	ELLIPTIC (arcsec)	MAGZPT (mag)
SMC 3_3	Y	800	1.210±0.094	0.075±0.013	23.382±0.095
	J	800	1.060±0.073	0.062±0.005	23.640±0.128
	K_s	750	0.997±0.098	0.068±0.017	23.057±0.030
SMC 3_5	Y	800	1.167±0.146	0.060±0.000	23.230±0.246
	J	800	0.980±0.165	0.060±0.000	23.667±0.064
	K_s	750	0.984±0.132	0.057±0.007	22.991±0.138
LMC 5_5	Y	800	0.980±0.150	0.067±0.005	23.427±0.010
	J	800	0.927±0.090	0.062±0.005	23.695±0.013
	K_s	750	0.843±0.056	0.061±0.011	23.045±0.047
LMC 6_4	Y	800	0.982±0.094	0.075±0.005	23.447±0.026
	J	800	0.955±0.104	0.077±0.010	23.687±0.005
	K_s	750	0.861±0.072	0.063±0.008	23.047±0.053
LMC 6_6	Y	800	1.120±0.099	0.072±0.010	23.702±0.017
	J	800	1.010±0.054	0.072±0.011	23.808±0.024
	K_s	750	0.932±0.062	0.059±0.008	23.064±0.104
LMC 8_3	Y	800	1.107±0.181	0.062±0.013	23.627±0.013
	J	800	1.072±0.144	0.065±0.013	23.650±0.303
	K_s	750	0.976±0.099	0.053±0.007	23.067±0.079
LMC 8_8	Y	800	1.097±0.118	0.060±0.008	23.605±0.006
	J	800	0.998±0.059	0.060±0.010	23.812±0.019
	K_s	750	0.911±0.091	0.047±0.006	23.014±0.233

The data quality per co-added tile is as follows.

Tile	Filter	TEXPTIME/3 (s)	PSF_FWHM (arcsec)	ELLIPTIC (arcsec)	ABMAGLIM (5σ)	ABMAGSAT
SMC 3_3	Y	2400	1.2931	0.0501	22.091	12.406
	J	2400	1.0673	0.0589	22.098	12.856
	K_s	9000	1.0284	0.0550	22.468	13.125
SMC 3_5	Y	2400	1.1413	0.0489	22.564	12.491
	J	2400	0.9760	0.0481	22.798	13.084
	K_s	9325	1.0155	0.0453	22.661	13.128
LMC 5_5	Y	2400	1.1077	0.0567	21.374	13.129
	J	2400	0.9840	0.0566	21.391	13.291
	K_s	9000	0.9120	0.0512	21.822	13.352
LMC 6_4	Y	2400	0.9914	0.0598	20.701	13.112
	J	2400	0.9928	0.0582	20.726	13.191
	K_s	9000	0.9129	0.0490	21.253	13.391
LMC 6_6	Y	2400	1.0705	0.0588	21.346	13.194
	J	2800	1.0477	0.0572	21.259	13.187
	K_s	9290	1.0015	0.0437	21.636	13.185
LMC 8_3	Y	2400	1.0235	0.0565	22.352	13.120
	J	2400	1.0460	0.0436	22.113	12.946
	K_s	8975	1.0019	0.0405	22.445	13.280
LMC 8_8	Y	2400	1.1063	0.0402	22.563	12.997
	J	2800	1.0622	0.0433	22.577	13.133
	K_s	9400	0.9619	0.0363	22.583	13.461

The Times above correspond to the exposure times per pixel (for 2 detector overlaps). For co-added tiles they are usually equal to the sum of the times indicated for single tiles, but times may be larger in case of extra good quality images (those that meet the VMC observing constraints) and in the regions with >2 detector overlaps. They can also be smaller due to the exclusion of problematic images.

Release Notes

The data for this release were prepared by the Cambridge Astronomy Survey Unit (CASU), the Wide Field Astronomy Unit (WFAU), and the VMC team.

The main processing steps are described in Cross et al. (2012, A&A 548, A119) and Cross et al. (2009, MNRAS 399, 1730). Images were reduced and source lists extracted from individual tile images using the software suite provided by CASU (v1.3). Co-added images were outgested from the VISTA Science Archive and were produced only from data that meet the observing constraints for the VMC survey.

Data Reduction and Calibration

The procedures to reduce and calibrate the data are described in detail at: http://casu.ast.cam.ac.uk/surveys-projects/vista/technical/data-processing.

The astrometric and photometric quality of the data is described in detail at *http://casu.ast.cam.ac.uk/surveys-projects/vista/technical*.

In addition, the quality error bit flags assigned during post processing are listed at *http://horus.roe.ac.uk/vsa/ppErrBits.html*. These flags refer to quality issues of varying severity such as it is a deblended source or it contains bad pixels in the default aperture. They also indicate if a source is located in the under-exposed area of a tile or in detector #16. They appear as ppErrBits in the catalogues and can be used to refine object samples.

Known issues

These VISTA data may present the following issues, for which a full description is given in http://casu.ast.cam.ac.uk/surveys-projects/vista/technical/known-issues. A variable depth due to bad pixels in detectors #1, #4 and #16 as well as some bad rows. Point-like objects residuals of flatfielding, variable vignetting and spurious detections around bright stars. Some of these issues are recorded in the quality error bits flags assigned during post processing.

Data in this release comprise observations obtained prior to 20 November 2009 when detector #6 had an intermittently bad channel. Note also that 15% of the tile, corresponding to two edges, has only half the total effective exposure time.

Tiles suffer from a complex 10-20 mas systematic pattern due to residual WCS errors from the component pawprints and prior to 01.08.2012 to an inconsistent use of the ZPN projection, which results in a complex residual radial distorsion of up to +/- 100 mas.

Previous Releases

This data release consists of five new VMC survey tiles and it includes the re-reduced data of the two tiles LMC 6_6 and 8_8, which were previously released in VMC Data Release 2.

This is the first VMC data release to include pawprint images that, for example, can be used instead of the corresponding tile images for astrometric studies and for investigating photometric variations of bright sources.

This data was reduced with the version of CASU software 1.3 while data from the previous release (2) was reduced with versions 1.1. Photometric and astrometric differences between the two releases are as follows.

- A bug involving how the aperture 2 correction was calculated is now fixed and tile catalogues have now been regrouted to include this.
- Prior to regrouting all the stacked pawprint photometric zero-points were recomputed using the latest version of the photometric software. For high latitude fields this make little difference (1%) to the stability of the derived photometric system. For low latitude fields with high and spatially variable extinction this can provide corrections of ~10% to the calibration.
- Post regrouting, all the tile photometric zero-points have also been updated.
- ESO grades have been updated and they should now agreee with those supplied by ESO to the PIs directly. This affects the keywords ESOGRADE and OBSTATUS for all data products.
- All tile catalogues have been regrouted taking into account both detector level magnitude zero-points variations and atmospheric seeing variations. The typical improvement in the derived magnitudes over a tile is 1-2% where this fix had not been previously applied, though in cases of variable seeing or transparency it can be significantly larger than this. All data from 20101101 has already had this fix applied during normal pipeline processing.
- Note that WCS coefficients for PV2_3 and PV2_5 were changed from 42.0, -10000.0 pre-20101130 to 44.0, -10300.0 post-20101201. This changes the overall astrometric solution by less than 100 mas over the entire field. The pre-20101130 astrometry was not updated.
- The internal ZPN to TAN definition bug that affected tile products was fixed August 2012. All products post-20120801 use the corrected ZPN to TAN transformation. Earlier tile products remain affected by this systematic predictable pattern at the +/-100 mas level. All pawprint products are unaffected.
- Added keyword NUMSTDS which stores the number of 2MASS objects in the field of view of each chip or tile potentially usable for the astrometric solution.
- Tiles now inherit the nightly photometric information from pawprints (keywords affected NIGHTNUM, NIGHTZPT, NIGHTZRR).
- Added a GROUTED keyword to catalogues generated from tiles that have been grouted.
- RADECSYS keyword changes. Primary extension remains FK5 while secondary extensions have the value ICRS added. The RADECSYS in the primary header is FK5 as that was used in pointing the telescope and the primary header information is inherited from the raw data files. The extensions use ICRS since that is the correct description of the astrometric reference system used in the astrometric refinement. See http://star-www.rl.ac.uk/docs/sun67.htx/node221.html for more details on the difference between FK5 and ICRS.
- Added new keywords to the tile primary header. PAWMAGZP, PAWELLPT and PAWSEENG which summarize the median values of the zero point, ellipticity and seeing from originating pawprint images to aid in QC procedures.
- The magnitude zero point error estimate for tiles is now calculated from the zero-point variation in the component pawprint images. This refers to the PHOTZPER , i.e. error in magnitude zero-point, for the calibration.

Data Format

Files Types

There are 179 individual tile images, each with six corresponding pawprints, and associated confidence maps and source lists with the adopted naming convention:

Pawprint images: v????????_?????_st.fits.fz
Associated confidence map: v????????_?????_st_conf.fits.fz
Source list per pawprint: v????????_?????_st_cat.fits
where the name is constructed as observing-date_number_type.fits(.fz)

Tile images: v????????_?????_st_tl.fits.fz
Associated confidence map: v????????_?????_st_tl_conf.fits.fz
Source list per tile: v????????_?????_st_tl_cat.fits
where the name is constructed as observing-date_number_type.fits(.fz)

There are 42 co-added tile images/confidence maps, e.g.
vmc_er3_05h37-069d22_tile_j_deepconf_3154269.fits.fz
vmc_er3_05h37-069d22_tile_j_deepimage_3154332.fits.fz
where the name is constructed as project_release_ra/dec_tile_ band_type_multiframeID.fits
and multiframeID uniquely identifies each FITS image.

These have 42 associated JPEG images, e.g.
vmc_er3_05h37-069d22_tile_j_jpeg_3154269.jpg
vmc_er3_05h37-069d22_tile_j_jpeg_3154332.jpg

Then there are 252 (12x3x7) associated deep paw-prints and their confidence maps, e.g.
vmc_er3_05h36-069d16_off0_j_deepconf_3154208.fits.fz
vmc_er3_05h36-069d16_off0_j_deepimage_3152706.fits.fz.

Then there are 21 individual tile base lists, e.g.
vmc_er3_05h37-069d22_tile_j_cat_3154332.fits.

Acknowledgements

Please reference Cioni et al. 2011, A&A, 527, A116 and use the following statement in your articles when using these data: Based on data products from observations made with ESO Telescopes at the La Silla Paranal Observatory under programme ID 179.B-2003.