Data Collection	VMC_CAT
Release Number	1
Data Provider	Maria-Rosa Cioni
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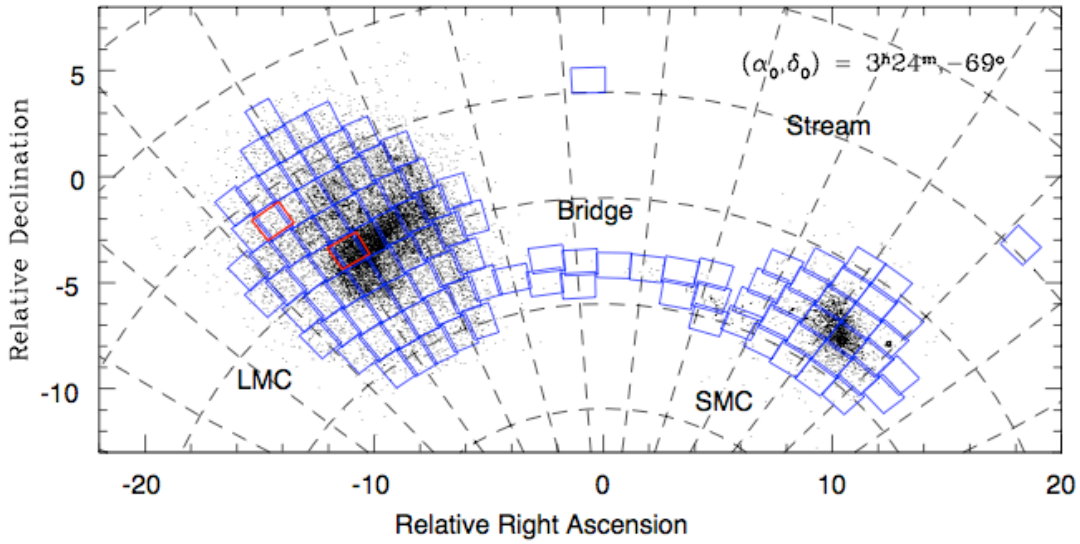
Abstract

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 Ks. 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 Ks mean magnitudes for pulsating variable stars, e.g. RR Lyrae stars and Cepheids.

This catalogue data release refers to deep tile images for VMC tiles completed by end of September 2011. These are tiles LMC 6_6 (including the 30 Doradus star forming region) and LMC 8_8 (including the South Ecliptic Pole region). Deep images are obtained from the combination of at least three epochs in Y and J filters and twelve epochs in Ks filter. The total sky coverage of this release is ~3.5 deg^2 in the LMC.

Overview of Observations

The figure below shows the Magellanic system as tiled by the VMC survey (blue) and tiles for which catalogues 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 right. 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.



Release Content

This catalogue release covers two tiles in the Large Magellanic Cloud: LMC 6_6 and LMC 8_8.

LMC tiles were oriented with the Y axis more or less along the declination direction and cover about 1.771 deg^2 each 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, number of records, size in Mby, limiting magnitude (MAGAPER3) in Y, J and Ks corresponding to sources with photometric errors APERMAG3ERR<0.1 mag are listed below.

Tile	RA	Dec	Records	Mby	Y	J	Ks
LMC 6_6	05:37:40.008	-69:22:18.120	1072852	486	19.9055	19.5142	18.9949
LMC 8_8	05:59:23.136	-66:20:28.680	758470	344	21.0907	20.7599	19.8561

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 Hambly et al. (2008, MNRAS 384, 637) and Cross et al. (2009, MNRAS 399, 1730). Epoch-merged and band-merged catalogues were extracted from deep tiles using the software suite provided by CASU (v1.1) and outgested from the VISTA Science Archive by WFAU using data in the VMCv20110909 release. Deep tiles are produced only from data that meet the observing criteria for the VMC survey.

Sources are unique within each tile. Where PRIORSEC>0 signifies that a source is located in a region of overlap with an adjacent tile that is not yet part of the current release.

The area over which the variability analysis is performed (VMC_CAT.VARFLAG) is 1.38 deg^2. The ears of tiles are excluded because of their lower exposure time compared to the tile centre and the region covered by detector #16 is also excluded because of the variable quantum efficiency.

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.

In particular, catalogues were created from images that were filtered for nebulosity with size of the order of 30 arcsec (Irwin 2010, UKIRT Newsletter 26, 14).

Individual pass-band detections are merged into multi-colour lists. The band-merging procedure is outlines in detail at http://horus.roe.ac.uk/vsa/dboverview.html. It is based on matching pairs of frames from short to long wavelength, and early to late epochs. The pairing tolerance for the VMC survey is of 1.0 arcsec. This radius is larger than the typical astrometric errors and may induce some level of spurious matchings. Matching objects in the overlap regions of detectors are ranked according to their filter coverage, then their quality error flags and finally their proximity to a detector edge. The final band-merged catalogue includes only sources that do not have duplicate measurements.

The magnitudes were not corrected for reddening.

Data Quality

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. For each pass-band nine quality issues are implemented as follows, where the corresponding value of the ppErrBit is given in parenthesis. Source is deblended source (16), has bad pixel(s) in default aperture (64), has low confidence in default aperture (128), lies within detector #16 region of a tile (4096), is close to saturation (65536), has photometric calibration probably subject to systemtic errors (131072), lies within a dither offset of the stacked frame boundary (4194304), lies within the underexposed strip of a tile (8388606), and lies within an underexposed region of a tile due to missing detector (16777216).
To select only sources without quality issues the user can filter on ppErrBits = 0, but note that the majority of the sources will have at least ppErrBits=16 due to the dense stellar field, and to include only sources with minor quality issues use ppErrBits < 256.

The completeness of the catalogues was evaluated from artificial star tests and PSF photometry.

Completeness	95%	90%	75%	50%
LMC 6_6				
Y	17.4	18.1	19.4	20.5
J	16.9	17.6	19.0	20.2
Ks	16.4	17.2	18.8	20.0
LMC 8_8				
Y	19.3	20.2	21.3	22.1
J	19.2	20.0	21.1	21.7
Ks	18.5	19.5	20.3	20.6

Known issues

Missing Ks detections - There are missing Ks band detections in the VMC deep tiles used in the science catalogues. The missing detections appear as a grid like distribution. This grid distribution matches the areas of overlap of all six paw-prints in the tile, where the confidence image should have maximal values. However, it was found that the confidence in these regions was negative, leading to non-detections. Further tests revealed the source of the problem: the science images had been scaled to store the floating-point data as integers so that the images could be losslessly compressed and this scaling was inadvertently applied to the confidence images. The BSCALE values depend on the NDIT and NJITTER. The NDIT values are particularly high for the VMC Ks band images, and the BSCALE is correspondingly lower, so it is only the VMC deep Ks tiles that are affected.

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.

The magnitudes in these VISTA catalogues may present offsets of 0.02 mag compared to previous analysis of the data due to problems in the zero-point calculation. More details are given at http://horus.roe.ac.uk/vsa/knownIssues.html#vmczp.

Previous Releases

The present data release refers to catalogues extracted from the reduced images available in VMC

Data Release 2 as of 28.06.2013.

Data Format

Files Types

Two epoch-merged and band-merged master source catalogues in YJKs, one per tile, are released:

vmc_er2_05h37-069d22_yjks_finalSourceCat_558345748491.fits
vmc_er2_05h59-066d20_yjks_finalSourceCat_558345748486.fits

where the name is constructed as project_release_ra/dec_bands_typeofCat_framesetID.fits
and framesetID uniquely identifies the tile as follows:

558345748486 LMC 8_8
558345748491 LMC 6_6.

A MetaData file, vmc_er2_yjks_catMetaData.fits, accompanies the release. Its name refers to project_release_bands_typeofCat.fits.

Catalogue Columns

Each epoch-merged and band-merged catalogue contains 96 columns listed below of which the 15 most relevant to guide user selections are: IAUNAME, sourceID, ra2000, dec2000, mergedClass, yAperMag3, yAperMag3Err, yErrBits, jAperMag, jAperMag3Err, jErrBits, ksAperMag3, ksAperMag3Err, ksErrBits, VARFLAG.

Number; name; format; description

1; IAUNAME; 36A; Unique identifier in IAU naming convention
2; SOURCEID; K; UID (unique over entire VSA via programme ID prefix) of this merged detection as assigned by merge algorithm
3; CUEVENTID; J; UID of curation event giving rise to this record
4; FRAMESETID; K; UID of the set of frames that this merged source comes from
5; RA2000; D; Celestial Right Ascension
6; DEC2000; D; Celestial Declination
7; CX; D; unit vector of spherical co-ordinates
8; CY; D; unit vector of spherical co-ordinates
9; CZ; D; unit vector of spherical co-ordinates
10;HTMLID; K; Hierarchical Triangular Mesh (HTM) index, 20 deep, for equatorial co-ordinates
11; L; D; Galactic longitude
12; B; D; Galactic latitude
13; LAMBDA; D; SDSS system spherical co-ordinate 1
14; ETA; D; SDSS system spherical co-ordinate 2
15; PRIORSEC; K; Seam code for a unique (=0) or duplicated (!=0) source (eg. flags overlap duplicates).
16; YMJPNT; E; Point source colour Y-J (using aperMag3)
17; YMJPNTERR; E; Error on point source colour Y-J
18; JMKSPNT; E; Point source colour J-Ks (using aperMag3)
19; JMKSPNTERR; E; Error on point source colour J-Ks
20; YMJEXT; E; Extended source colour Y-J (using aperMagNoAperCorr3)
21; YMJEXTERR; E; Error on extended source colour Y-J
22; JMKSEXT; E; Extended source colour J-Ks (using aperMagNoAperCorr3)
23; JMKSEXTERR; E; Error on extended source colour J-Ks
24; MERGEDCLASSSTAT; E; Merged N(0,1) stellarness-of-profile statistic
25; MERGEDCLASS; I; Class flag from available measurements (1|0|-1|-2|-3|-

9=galaxy|noise|stellar|probableStar|probableGalaxy|saturated)
26; PSTAR; E; Probability that the source is a star
27; PGALAXY; E; Probability that the source is a galaxy
28; PNOISE; E; Probability that the source is noise
29; PSATURATED; E; Probability that the source is saturated
30; YPETROMAG; E; Extended source Y mag (Petrosian)
31; YPETROMAGERR; E; Error in extended source Y mag (Petrosian)
32; YAPERMAG3; E; Default point source Y aperture corrected mag (2.0 arcsec aperture diameter)
33; YAPERMAG3ERR; E; Error in default point/extended source Y mag (2.0 arcsec aperture diameter)
34; YAPERMAG4; E; Point source Y aperture corrected mag (2.8 arcsec aperture diameter)
35; YAPERMAG4ERR; E; Error in point/extended source Y mag (2.8 arcsec aperture diameter)
36; YAPERMAG6; E; Point source Y aperture corrected mag (5.7 arcsec aperture diameter)
37; YAPERMAG6ERR; E; Error in point/extended source Y mag (5.7 arcsec aperture diameter)
38; YAPERMAGNOAPERCORR3; E; Default extended source Y aperture mag (2.0 arcsec aperture diamter)
39; YAPERMAGNOAPERCORR4; E; Extended source Y aperture mag (2.8 arcsec aperture diameter)
40; YAPERMAGNOAPERCORR6; E; Extended source Y aperture mag (5.7 arcsec aperture diameter)
41; YGAUSIG; E; RMS of axes of ellipse fit in Y
42; YELL; E; 1-b/a, where a/b=semi-major/minor axes in Y
43; YPA; E; ellipse fit celestial orientation in Y
44; YERRBITS; J; processing warning/error bitwise flags in Y
45; YAVERAGECONF; E; average confidence in 2 arcsec diameter default aperture (aper3) Y
46; YCLASS; I; discrete image classification flag in Y
47; YCLASSSTAT; E; N(0,1) stellarness-of-profile statistic in Y
48; YPPERRBITS; J; additional WFAU post-processing error bits in Y
49; YSEQNUM; J; the running number of the Y detection
50; YXI; E; Offset of Y detection from master position (+east/-west)
51; YETA; E; Offset of Y detection from master position (+north/-south)
52; JPETROMAG; E; Extended source J mag (Petrosian)
53; JPETROMAGERR; E; Error in extended source J mag (Petrosian)
54; JAPERMAG3; E; Default point source J aperture corrected mag (2.0 arcsec aperture diameter)
55; JAPERMAG3ERR; E; Error in default point/extended source J mag (2.0 arcsec aperture diameter)
56; JAPERMAG4; E; Point source J aperture corrected mag (2.8 arcsec aperture diameter)
57; JAPERMAG4ERR; E; Error in point/extended source J mag (2.8 arcsec aperture diameter)
58; JAPERMAG6; E; Point source J aperture corrected mag (5.7 arcsec aperture diameter)
59; JAPERMAG6ERR; E; Error in point/extended source J mag (5.7 arcsec aperture diameter)
60; JAPERMAGNOAPERCORR3; E; Default extended source J aperture mag (2.0 arcsec aperture diameter)
61; JAPERMAGNOAPERCORR4; E; Extended source J aperture mag (2.8 arcsec aperture diameter)
62; JAPERMAGNOAPERCORR6; E; Extended source J aperture mag (5.7 arcsec aperture diameter)
63; JGAUSIG; E; RMS of axes of ellipse fit in J
64; JELL; E; 1-b/a, where a/b=semi-major/minor axes in J
65; JPA; E; ellipse fit celestial orientation in J
66; JERRBITS; J; processing warning/error bitwise flags in J
67; JAVERAGECONF; E; average confidence in 2 arcsec diameter default aperture (aper3) J
68; JCLASS; I; discrete image classification flag in J
69; JCLASSSTAT; E; N(0,1) stellarness-of-profile statistic in J
70; JPPERRBITS; J; additional WFAU post-processing error bits in J
71; JSEQNUM; J; the running number of the J detection
72; JXI; E; Offset of J detection from master position (+east/-west)
73; JETA; E; Offset of J detection from master position (+north/-south)
74; KSPETROMAG; E; Extended source Ks mag (Petrosian)
75; KSPETROMAGERR; E; Error in extended source Ks mag (Petrosian)
76; KSAPERMAG3; E; Default point source Ks aperture corrected mag (2.0 arcsec aperture diame-

ter)
77; KSAPERMAG3ERR; E; Error in default point/extended source Ks mag (2.0 arcsec aperture diameter)
78; KSAPERMAG4; E; Point source Ks aperture corrected mag (2.8 arcsec aperture diameter)
79; KSAPERMAG4ERR; E; Error in point/extended source Ks mag (2.8 arcsec aperture diameter)
80; KSAPERMAG6; E; Point source Ks aperture corrected mag (5.7 arcsec aperture diameter)
81; KSAPERMAG6ERR; E; Error in point/extended source Ks mag (5.7 arcsec aperture diameter)
82; KSAPERMAGNOAPERCORR3; E; Default extended source Ks aperture mag (2.0 arcsec aperture diameter)
83; KSAPERMAGNOAPERCORR4; E; Extended source Ks aperture mag (2.8 arcsec aperture diameter)
84; KSAPERMAGNOAPERCORR6; E; Extended source Ks aperture mag (5.7 arcsec aperture diameter)
85; KSGAUSIG; E; RMS of axes of ellipse fit in Ks
86; KSELL; E; 1-b/a, where a/b=semi-major/minor axes in Ks
87; KSPA; E; ellipse fit celestial orientation in Ks
88; KSERRBITS; J; processing warning/error bitwise flags in Ks
89; KSAVERAGECONF; E; average confidence in 2 arcsec diameter default aperture (aper3) Ks
90; KSCLASS; I; discrete image classification flag in Ks
91; KSCLASSSTAT; E; N(0,1) stellarness-of-profile statistic in Ks
92; KSPPERRBITS; J; additional WFAU post-processing error bits in Ks
93; KSSEQNUM; J; the running number of the Ks detection
94; KSXI; E; Offset of Ks detection from master position (+east/-west)
95; KSETA; E; Offset of Ks detection from master position (+north/-south)
96; VARFLAG; J; Classification of objects across all bands.

The format refers to the fits notation as follows:
A - string 32 characters; D - double floating point (8 bytes); E - real floating point (4 bytes); I - short integer (2 bytes); J - integer (4 bytes); K - long integer (8 bytes).

The variability flag is described in detail in Cross et al. (2009, MNRAS, 399, 1730). It is set to true (1) or false (0) using the sum of the weighted ratios of the intrinsic standard deviation to the expected noise. The weighting in each filter depends on the number of observations in each filter. At least five observations in one filter are needed for an object to be counted as variable. Thus, for the VMC data this is driven by observations in the Ks band only.

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.