Data Collection	*VVV_MPHOT_KS*
Release Number	2
Data Provider	D. Minniti, P. Lucas and the VVV team
Date	19.08.2015

ESO Science Archive Facility - Phase 3 Data Release Description
ESO public survey programme VVV - VISTA Variables in the Via Lactea Survey, Data Release DR2
provided by Dante Minniti, published on 2015-08-19

Abstract

The VVV Survey data delivered in this part of ESO Data Release 2 (DR2) includes the VISTA/VIRCAM paw-print and tile images that were acquired until September 30, 2011, and processed by the Cambridge Astronomical Survey Unit (CASU). This "VVV_MPHOT_KS" data release contains the multi-epoch Ks catalogues for each VVV tile. The corresponding images have already been released in the part of DR2 identified as Batch 2 "VVV" in the ESO archive. VVV_MPHOT_CAT contains 348 tile catalogues.

Overview of Observations

The VVV photometry is divided into different disk and bulge tiles. The tile nomenclature goes from d001 to d152 in the disk, and from b201 to b396 in the bulge. The map with the field IDs is shown in Figures 1a and 1b, overlapped on the extinction map of the inner Milky Way from Schlegel et al.(1998, ApJ, 500, 525).

For each VISTA tile, the Ks images at each epoch were usually obtained in an OB that included 4 tiles. The exception is the master images, which were obtained in an OB with contemporaneous JHKs photometry. The integration time on source was usually 16 s at each epoch, with the exception of the master images in the disk region, which had 80 s integration time on source.

Release Content

The VVV Survey observations planned for Years 1 and 2 (ESO Periods 85 and 87) comprised JHKs maps as first priority, ZY maps as second priority, and 25 epochs in the Ks-band, for the entire bulge and disk fields (all 348 tiles covering >520 sqdeg). This batch 2 of files in the VVV_CAT collection contains the bandmerged ZYJHKs catalogues generated from data taken up to 30 Sep 2011.

The DR2 variability data is illustrated in Figure 2. The coordinates given in the catalogues are an average of the coordinates in each passband, weighted according to the errors. In total, the catalogues contain 2,561,652,334 flux measurements from 379,558,809 sources. Catalogues in the disk region are typically deeper than the bulge

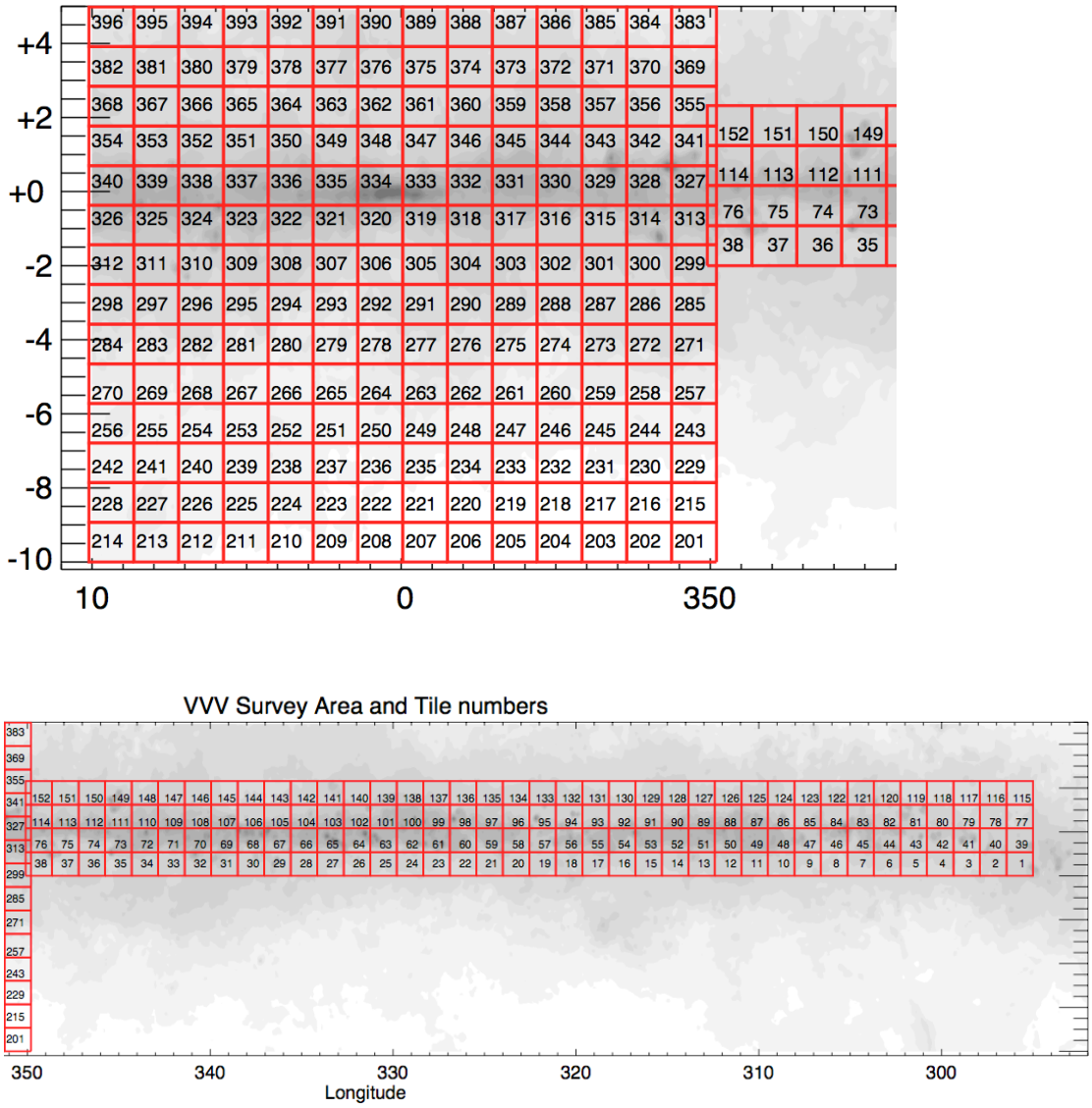

Figure 1. Maps showing the VVV tile numbers for: (a) bulge (upper panel); and (b) disk (lower panel).

region, owing to lower source confusion. The 5 sigma photometric limits for isolated sources in the disc region are typically Ks=17.2 for the 16 s integrations and Ks=18.0 for the 80 s integrations. In the bulge region the limits vary widely, so it is not useful to quote a single figure for each passband. Note that the quoted errors do not take account of blending between adjacent sources, although the aperture photometry does deblend the fluxes in adjacent overlapping apertures.

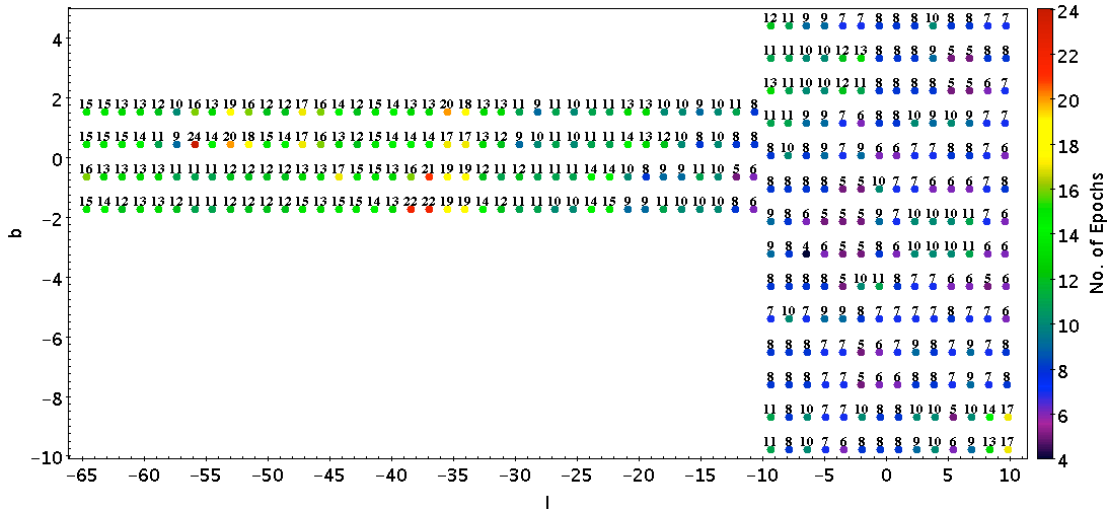

Figure 2. Colour coded plot showing the number of Ks epochs of observation for each tile in this release.

Release Notes

Data Reduction and Calibration

The pipeline is composed of the following mains steps: reset correction, dark current subtraction, linearity correction, flat field correction, sky background correction, de-striping (removal of a consistent electronic signal pattern from the arrays), illumination correction, image stacking into tiles, catalogue generation and then astrometric and photometric calibration. The sky background correction is based on the combination of 24 distinct VISTA pointings over 2 consecutive tiles imaged in the same OB, which has proven to be sufficient to remove stars in crowded VVV fields.)

The following procedures are done on an individual tile basis.
The photometric calibration on to the VIRCAM (Vega-based) photometric system is derived from the 2MASS Point Source Catalogue, using relatively blue 2MASS sources with JHKs detections with <0.1 mag uncertainties in all 3 passbands, 0<(J-Ks)<2 (as observed in 2MASS) and 0 < (J-Ks) < 1 (after dereddening the 2MASS sources individually using a prescription involving the Schlegel COBE/DIRBE extinction maps. Linear transformations between the 2MASS and VIRCAM photometric systems were applied that incorporate a colour term (based on 2MASS colours) and an extinction term (based on the Schlegel maps). Aperture corrections are different for the 104 different sections of each VIRCAM tile (made from 6 pointings of the 16 arrays) and this is accounted for in the calibration after generation of the tiles and construction of initial tile catalogues.

An overlap analysis between adjacent tiles was used to confirm that nearly all tiles have consistent calibrations, though further small improvements are being made as the pipeline is continuously improved. The files in this release

were reduced using v1.1 or v1.2 of the pipeline developed by the Cambridge Astronomical Survey Unit (CASU), v1.2 being used for observations after 1 May 2011. The minor differences between the 2 versions affect only the headers of the unmerged catalogues so there is no difference between the v1.1 and v1.2 catalogue products in this collection.

Aperture-corrected source magnitudes are provided in a 2 arcsec diameter aperture, for the magnitudes given in this “VVV_MPHOT_KS” data collection. The astrometric calibration is relative to the 2MASS Point Source Catalogue, with a typical precision of 0.08 arcsec for bright isolated stars.

Source detection requires 4 contiguous simply-connected pixels to be above a detection threshold set at 1.5 times the r.m.s. sky noise. Prior to source detection, the tile images are spatially filtered to remove the pattern of joins between the 96 components sections of a tile using a ~30 arcsec spatial filter. Nebulosity on smaller scales (e.g. in star formation regions) is not removed and this can affect detection and photometry of faint stars. Note that the spatial filter was not used on the tile images in the “VVV” data collection, only from the images used for source detection.

Quality Control

Visual Quality Control was performed in different steps. All the jpeg images of each tile were visually inspected and removed to remove tiles with obvious defects, e.g. highly non-uniform background, image profile defects due to lost guiding, problems with the active optics or electronic instability in the camera. Then, visual quality control of VVV tiles was made on a fraction of the FITS images. A word of caution: this intense activity is continuing, and even though we checked the images for defects, we are still identifying images that need to be reprocessed or reacquired.

The Quality Control for the Phase 3 data was performed on the paw-prints and tiles with involvement of most of the scientists from the team. Algorithmic quality control cuts to remove images with low zero points (after correcting for the seasonal trend), seeing that was significantly outside specification, or high average ellipticity were applied. There are a number of well known small image defects intrinsic to the VISTA/VIRCAM arrays, many of which are illustrated with pictures in the CASU and VVV web pages (document vvv_defects.pdf).

Known Issues

Users of the catalogues should be aware that ~1% of the area of each tile (at the top right, in pixel coordinates) suffers less reliable photometric calibration (particularly in the Z, Y and J passbands) owing to the poor quality of VISTA/VIRCAM detector no.16, whose quantum efficiency is highly variable in the upper part of the array. The region affected, and any other regions of below average data quality in a given tile, can be seen by inspecting the confidence images in the “VVV” data collection.

Users should also note that the sections of each tile near the left and right edge (in pixel coordinates) have half the normal exposure time since they lie at the edge of the standard VISTA tiling pattern. These sections are each 0.092 degrees in width. Again, they can be seen by inspecting the confidence images in the “VVV” data collection.

Bright saturated stars produce local maxima around them which are interpreted as detections by the extraction software. These spurious objects are typically classified as extended and many of them have large ellipticities.

Saturated objects also have a "hole" in their centre visible as a dark spot in the images. This is due to the double correlated sampling used during image readout.

The completeness of the tile catalogues is good in the “disk” portion of the VVV survey but less good in the bulge, where source confusion is highest. This is discussed in detail in the VVV DR1 publication (Saito et al.2012).

Data Format

Files Types

There is only 1 type of file in this data collection: the multi-epoch Ks tile catalogue FITS files.

Catalogue Columns

The formats are as follows. “A” = character string. “K”=64 bit integer. “D”=double precision. “E”= single precision. “I”=16 bit integer. “J”=32 bit integer.

PHOT_ID; K; Unique identifier for epoch observation.

IAUNAME; 29A; Unique identifier, following the IAU naming convention

sourceID; K; UID (unique over entire VSA via programme ID prefix) of this merged detection as assigned by the merge algorithm.

MJD; D; The mean Modified Julian Day of each detection

KSMAG; E; Calibrated and corrected magnitude in a 2 arcsec diameter aperture.

KSERR; E; Error in calibrated aperture magnitude.

Acknowledgements

Credit: the VVV team. The References are:

D. Minniti, P. W. Lucas, J. P. Emerson, R. K. Saito, M. Hempel, P. Pietrukowicz, A. V. Ahumada, M. V. Alonso, J. Alonso-García, J. I. Arias, R. M. Bandyopadhyay, R. H. Barbá, L. R. Bedin, E. Bica, J. Borissova, L. Bronfman, M. Catelan, J. J. Clariá, N. Cross, R. de Grijs, I. Dékány, J. E. Drew, C. Fariña, C. Feinstein, E. Fernández Lajús, R. C. Gamen, D. Geisler, W. Gieren, B. Goldman, O. González, G. Gunthardt, S. Gurovich, N. C. Hambly, M. J. Irwin, V. D. Ivanov, A. Jordán, E. Kerins, K. Kinemuchi, R. Kurtev, M. López-Corredoira, T. Maccarone, N. Masetti, D. Merlo, M. Messineo, I. F. Mirabel, L. Monaco, L. Morelli, N. Padilla, M. C. Parisi, G. Pignata, M. Rejkuba, A. Roman-Lopes, S. E. Sale, M. R. Schreiber, A. C. Schröder, M. Smith, L. Sodré Jr., M. Soto, M. Tamura, C. Tappert, M. A. Thompson, I. Toledo, M. Zoccali, "VISTA Variables in the Via Lactea (VVV): The public ESO near-IR variability survey of the Milky Way", 2010, New Astronomy, 15, 433

R. K. Saito, M. Hempel, D. Minniti, P. W. Lucas, M. Rejkuba, I. Toledo, O. A. Gonzalez, J. Alonso-García, M. J. Irwin, E. Gonzalez-Solares, S. T. Hodgkin, J. R. Lewis, N. Cross, V. D. Ivanov, E. Kerins, J. P. Emerson, M. Soto, E. B. Amôres, S. Gurovich, I. Dékány, R. Angeloni, J. C. Beamin, M. Catelan, N. Padilla, M. Zoccali, P. Pietrukowicz, C. Moni Bidin, F. Mauro, D. Geisler, S. L. Folkes, S. E. Sale, J. Borissova, R. Kurtev, A. V. Ahumada, M. V. Alonso, A. Adamson, J. I. Arias, R. M. Bandyopadhyay, R. H. Barbá, B. Barbuy, G. L. Baume, L. R. Bedin, A. Bellini, R. Benjamin, E. Bica, C. Bonatto, L. Bronfman, G. Carraro, A. N. Chenè, J. J. Clariá, J. R. A. Clarke, C. Contreras, A. Corvillón, R. de Grijs, B. Dias, J. E. Drew, C. Fariña, C. Feinstein, E. Fernández-Lajús, R. C. Gamen, W. Gieren, B. Goldman, C. González-Fernández, R. J. J. Grand, G. Gunthardt, N. C. Hambly, M. M. Hanson, K. G. Hełminiak, M. G. Hoare, L. Huckvale, A. Jordán, K. Kinemuchi, A. Longmore, M. López-Corredoira, T. Maccarone, D. Majaess, E. L. Martín, N. Masetti, R. E. Mennickent, I. F. Mirabel, L. Monaco, L. Morelli, V. Motta, T. Palma, M. C. Parisi, Q. Parker, F. Peñaloza, G. Pietrzyński, G. Pignata, B. Popescu, M. A. Read, A. Rojas, A. Roman-Lopes, M. T. Ruiz, I. Saviane, M. R. Schreiber, A. C. Schröder, S. Sharma, M. D. Smith, L. Sodré Jr., J. Stead, A. W. Stephens, M. Tamura, C. Tappert, M. A. Thompson, E. Valenti, L. Vanzi, N. A. Walton, W. Weidmann and A. Zijlstra, "VVV DR1: The first data release of the Milky Way bulge and southern plane from the near-infrared ESO public survey VISTA variables in the Vía Láctea", 2012, A&A, 537, A107

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