2MASS Photometry of Magellanic Clouds Star Clusters and Implications to SSP Models

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Introduction

* A part of a large effort to obtain accurate UV-through-mid-IR colors and integrated Lick and CaT spectral indices for a sample of SSP (GCs in our Galaxy and Magellanic Clouds)
* Aim - to provide the first multi-wavelength empirical color calibration and to improve the SSP models

* Importance of the NIR JHK colors for young and intermediate age stellar populations (0.5 - 3 Gyr) -> young galaxies at hight redshift
* Existing NIR data (Persson et al. 1983)
* 2MASS as an opportunity to improve the SSP models in NIR
* Why the Magellanic Clouds clusters? Sample selection

Data and Photometry

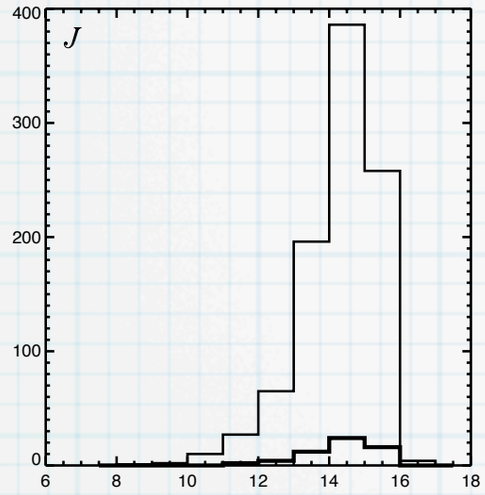
* The data was retrieved from the 2MASS Interactive Image Service: http://irsa.ipac.caltech.edu/applications/2MASS/IM/interactive.html

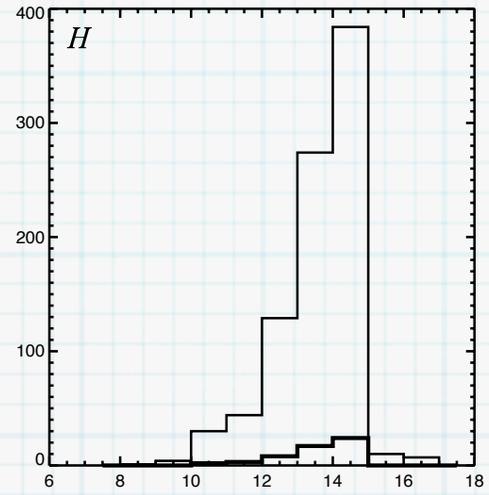
* Data reduction and photometry were performed with a suite of standard IRAF tasks and custom designed IDL scripts for some special purposes

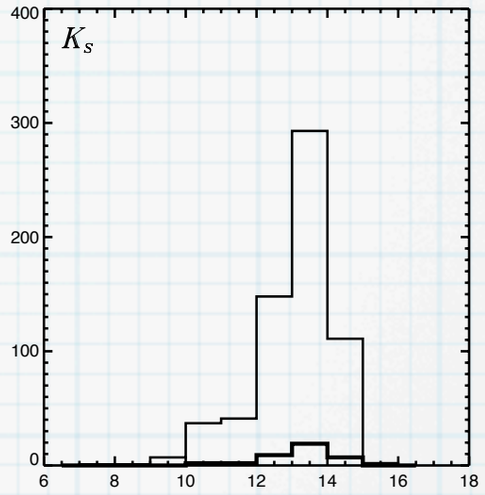
Data Reduction Steps

* DAOPHOT/ALLSTAR photometry of the Atlas Images
* Determination of the center for the integrated aperture photometry of the cluster
* Stellar foreground/background subtraction

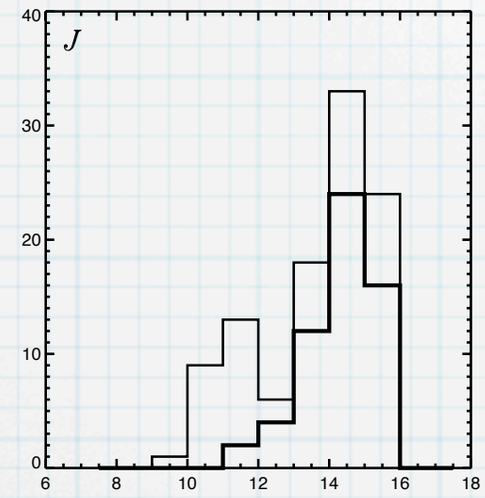
BACKGROUND FIELD

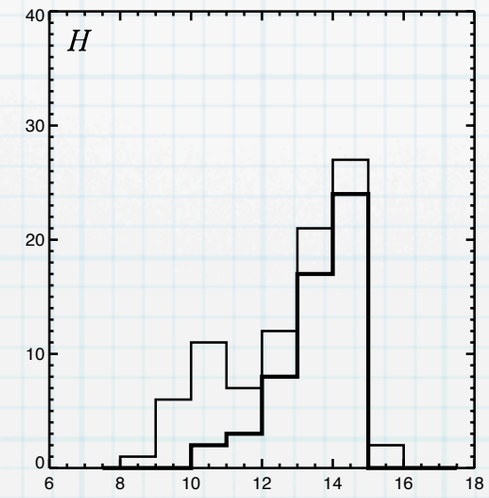


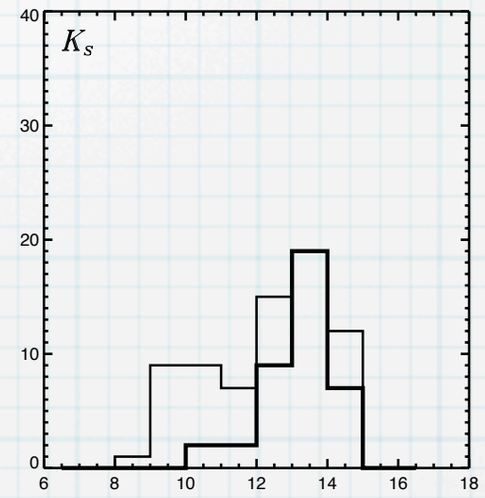




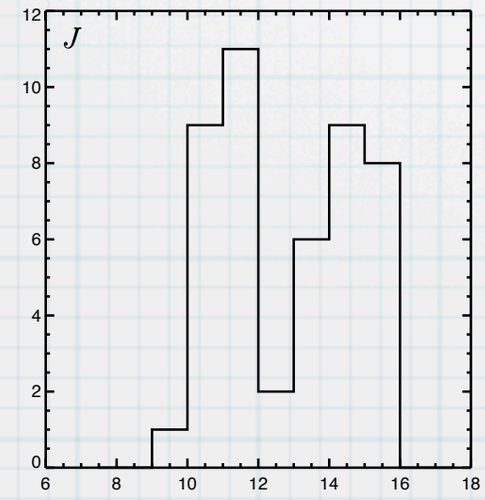
CLUSTER FIELD

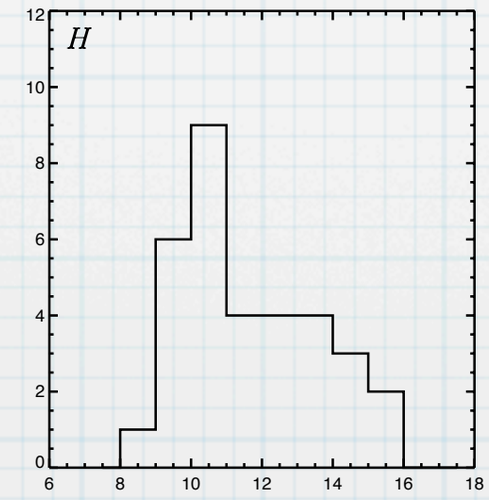


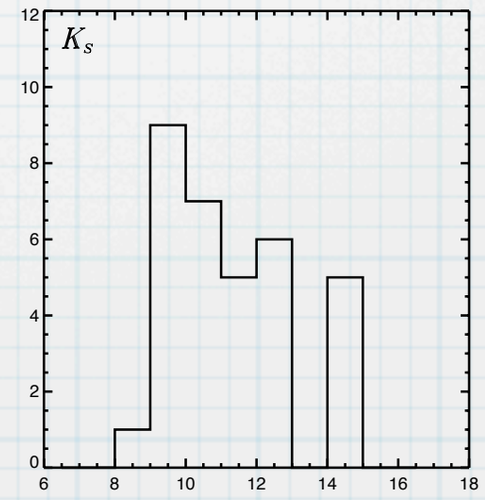




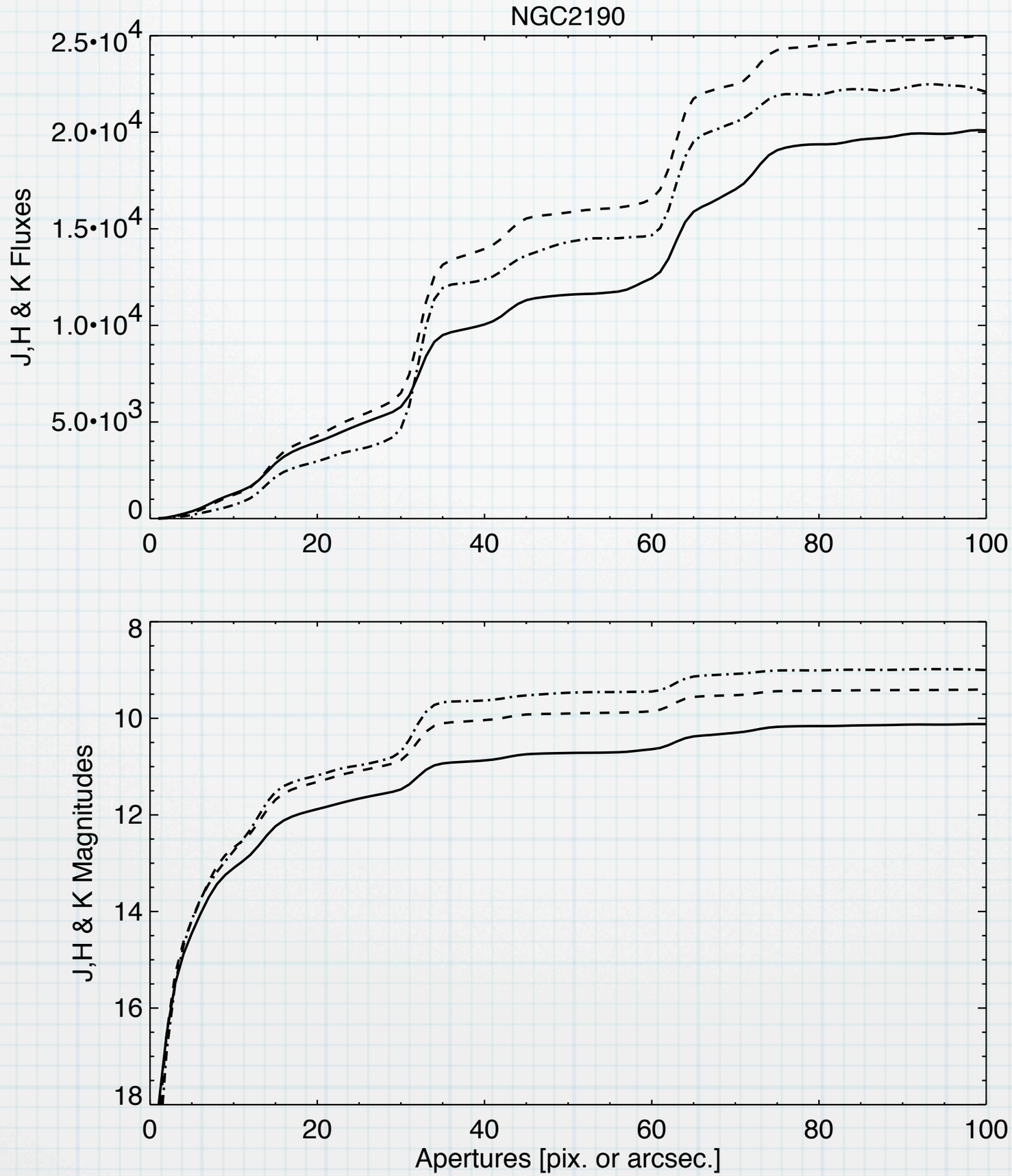
SUBTRACTED CLUSTER FIELD

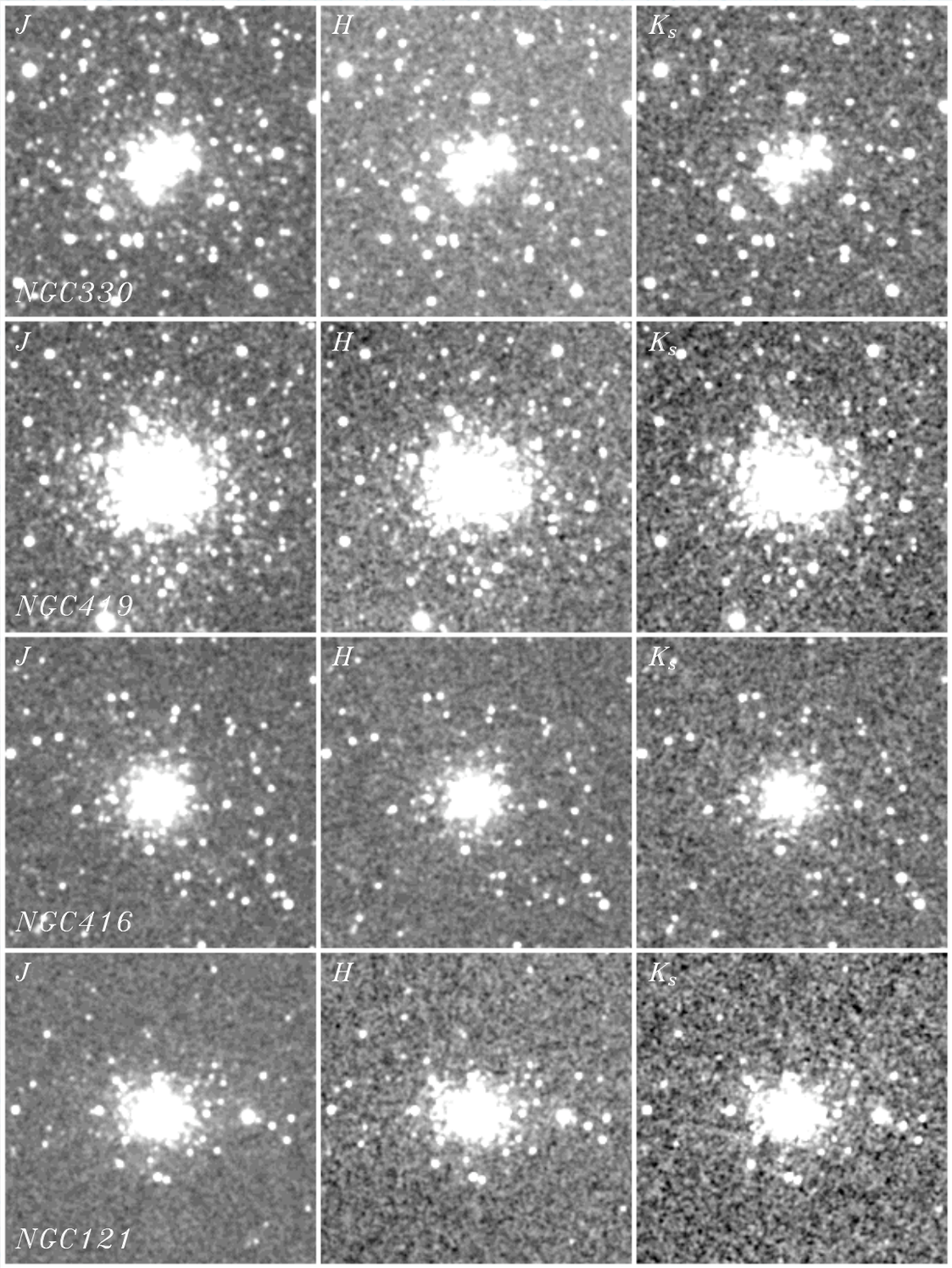


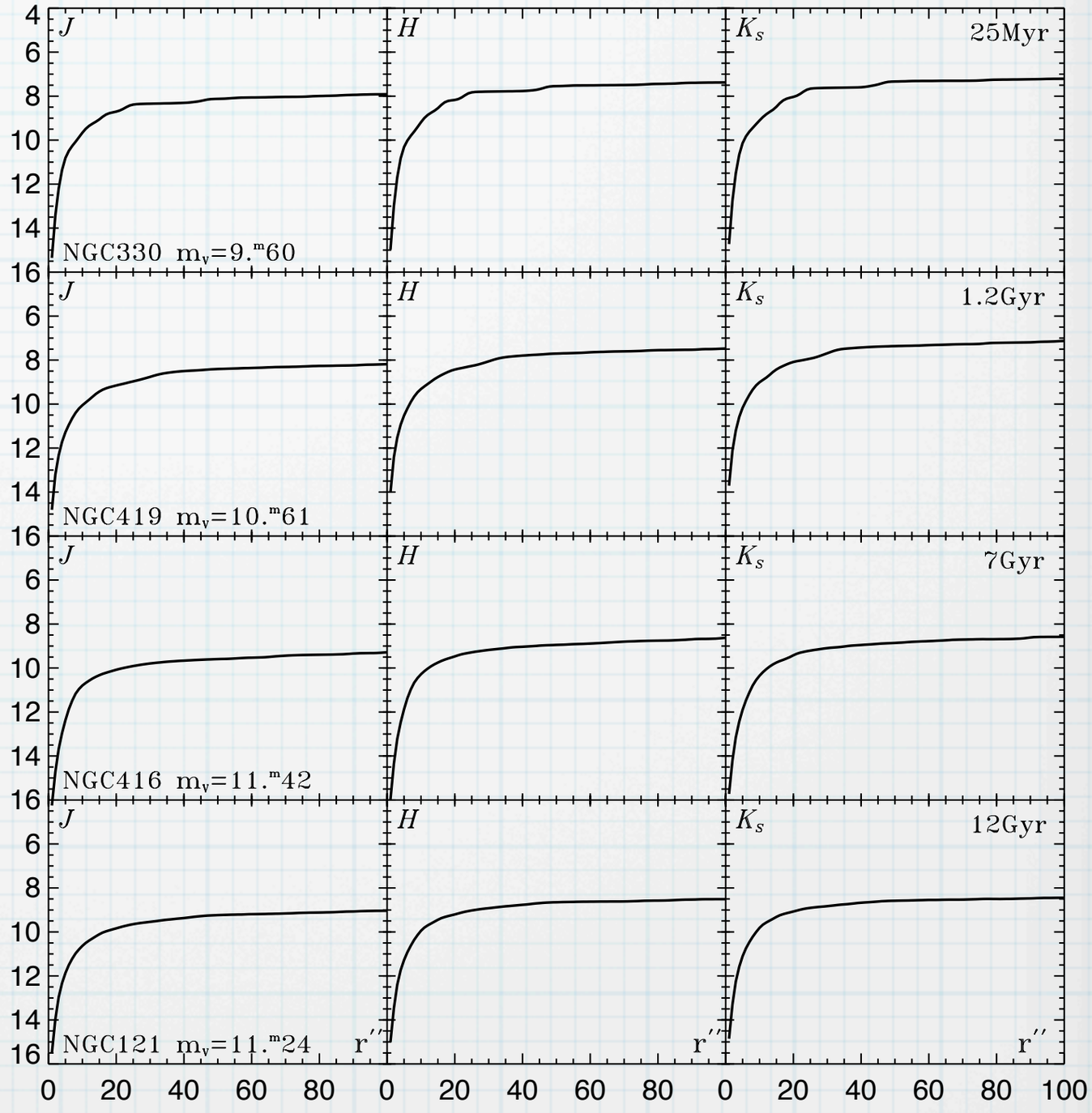


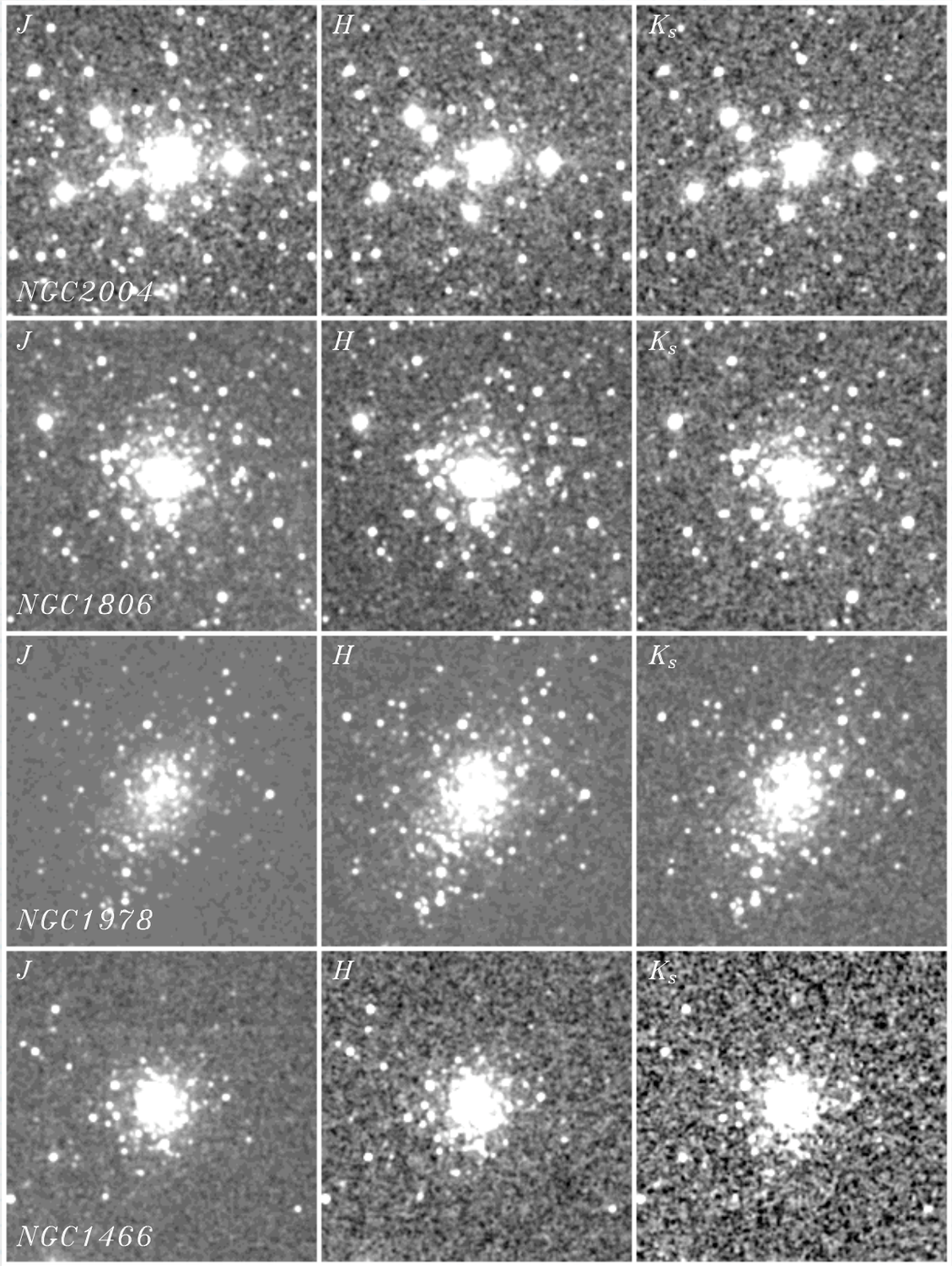


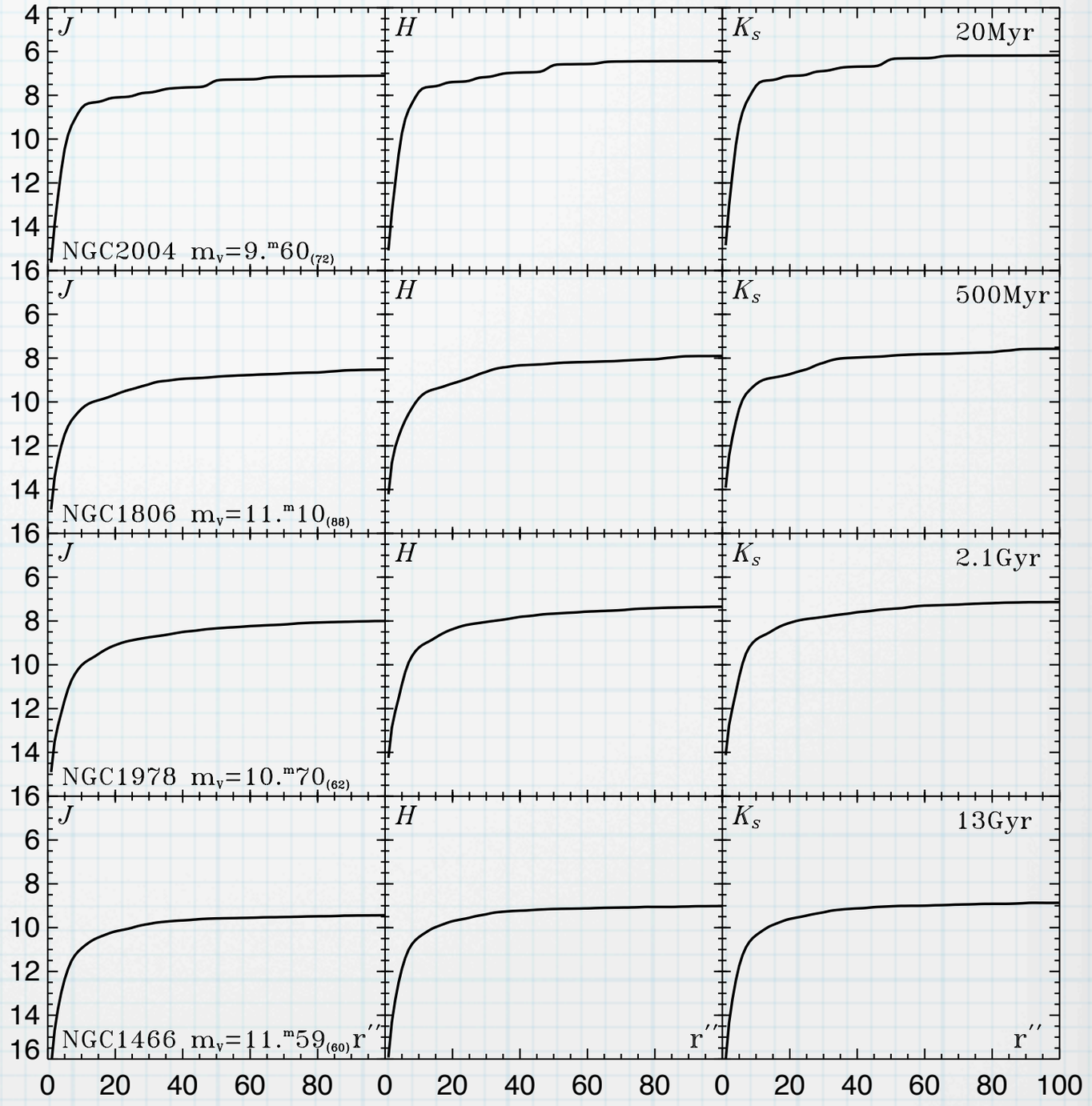
* Aperture photometry of the object
* Determination of the errors introduced by the stochastic fluctuations of the foreground/background
* Calculation of total errors of photometry
* Curves of growth for each 2MASS filter


NGC2190
J,H & K Fluxes
2.5•10^4
2.0•10^4
1.5•10^4
1.0•10^4
5.0•10^3
0
0
20
40
60
80
100
J,H & K Magnitudes
8
10
12
14
16
18
0
20
40
60
80
100
Apertures [pix. or arcsec.]


J
H
K_s
NGC330
J
H
K_s
NGC419
J
H
K_s
NGC416
J
H
K_s
NGC121


J
H
K_s
25Myr
NGC330 m_v=9.^{m}60
1.2Gyr
NGC419 m_v=10.^{m}61
7Gyr
NGC416 m_v=11.^{m}42
12Gyr
NGC121 m_v=11.^{m}24
r''
4
6
8
10
12
14
16
0
20
40
60
80
100


J
H
K_s
NGC2004
NGC1806
NGC1978
NGC1466

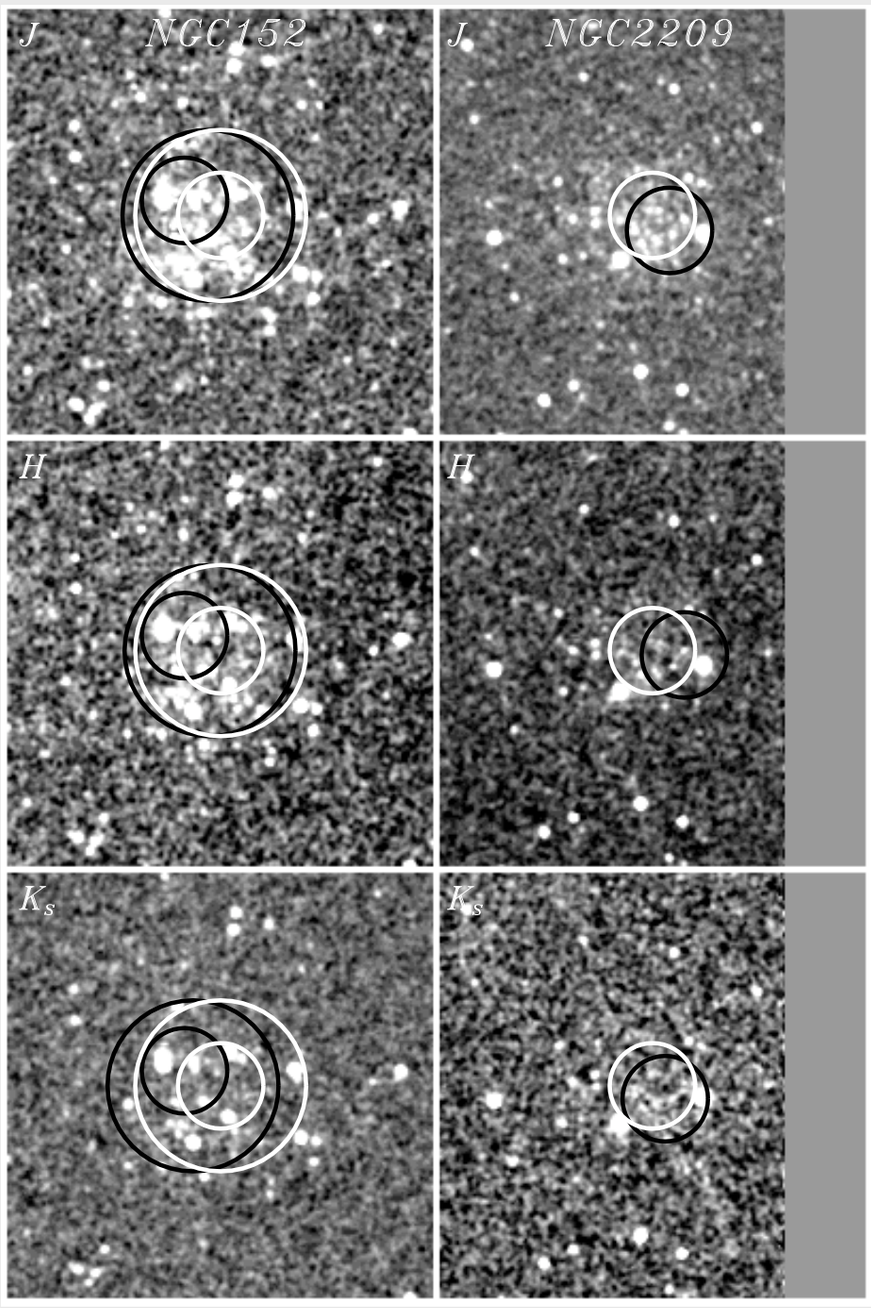

J
H
K_s
20Myr
500Myr
2.1Gyr
13Gyr
NGC2004 $m_v=9.^m60_{(72)}$
NGC1806 $m_v=11.^m10_{(88)}$
NGC1978 $m_v=10.^m70_{(62)}$
NGC1466 $m_v=11.^m59_{(60)}$
r''
4
6
8
10
12
14
16
0
20
40
60
80
100

Comparison with Persson et al. (1983)

* There are 52 clusters in common between our work and Persson et al. (1983)

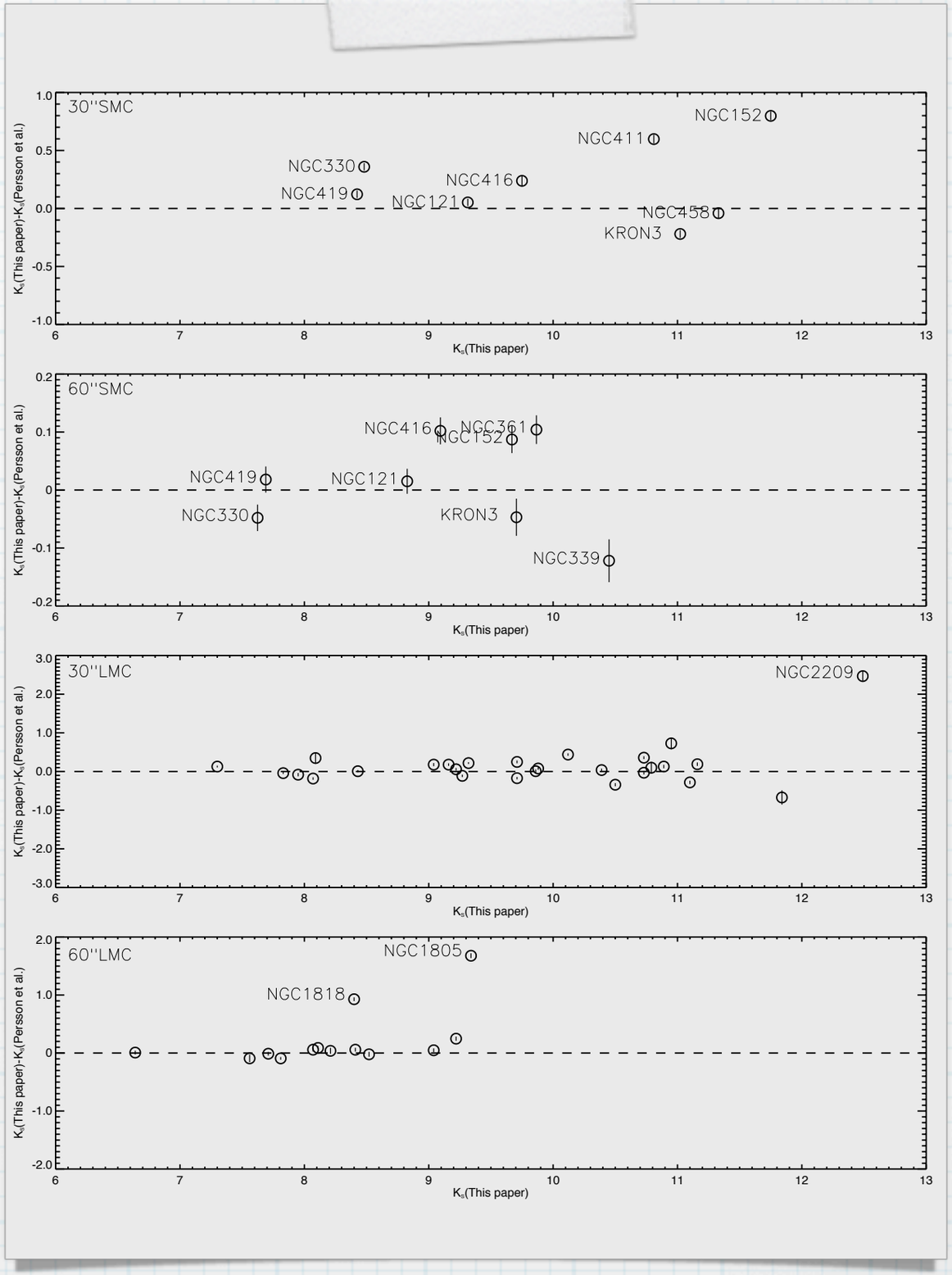
* K magnitudes, (J-K), and (H-K) colors are converted to 2MASS system by the transformation equations derived by Carpenter (2001), see: http://www.astro.caltech.edu/jmc/2mass/v3/transformations/ for the latest version and more details

Illustration of the centering in the two studies. The black circles are the reproduced apertures of Persson et al. (1983) for NGC152 in SMC (left) and NGC2209 in LMC (right). J, H and Ks images of each object are shown from top to bottom. The corresponding apertures from our work are overplotted with white. Taking into account the centering differences, there is a very good agreement between our results ant those of Persson et al.



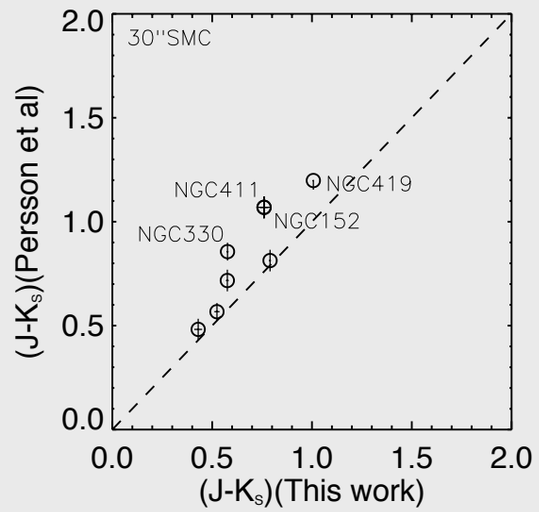
Ks ver Ks(Persson)

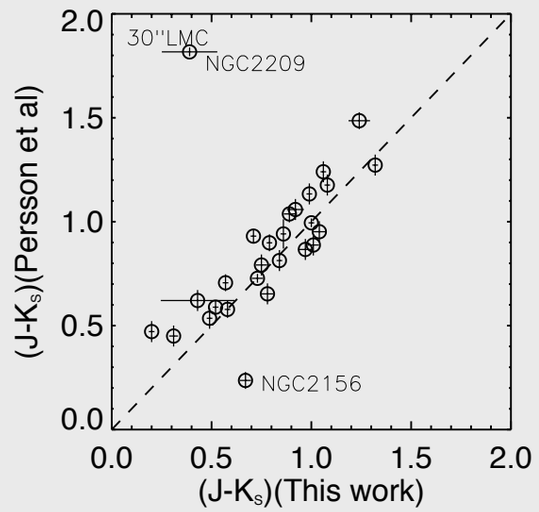
The difference between our Ks magnitudes and the values of Persson et al. (1983), as a function of our Ks magnitudes.
The upper 2 panels are 30" and 60" apertures for the SMC clusters in common. Lower panels are the same aperture sizes for the LMC clusters.

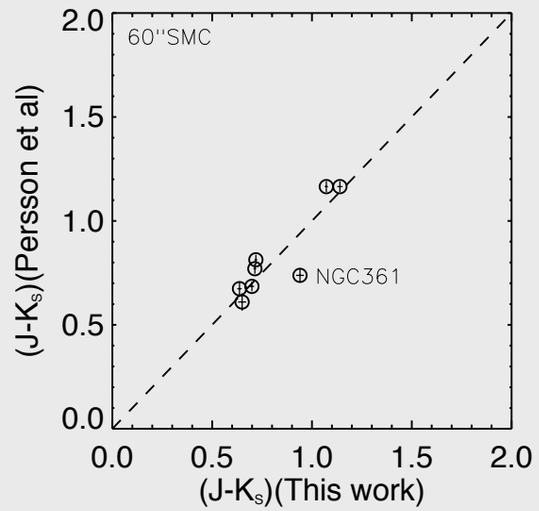


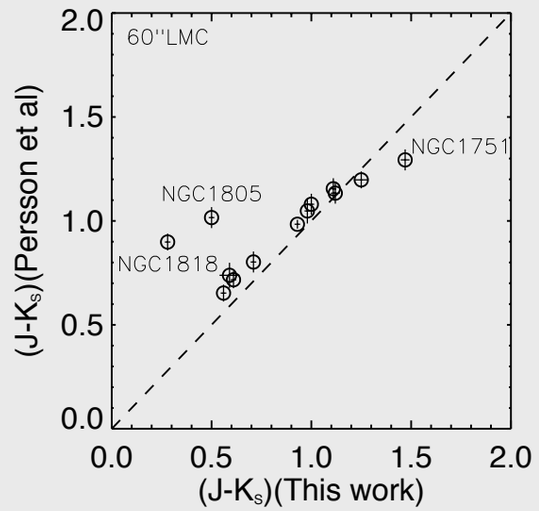
(J-Ks)Persson ver (J-Ks)

Comparison between our (J-Ks) colors and those, measured by a single-channel detector in 1983 for the SMC (left panels) and LMC clusters (right panels) in 30'' (up) and 60''(down) aperture diameter.



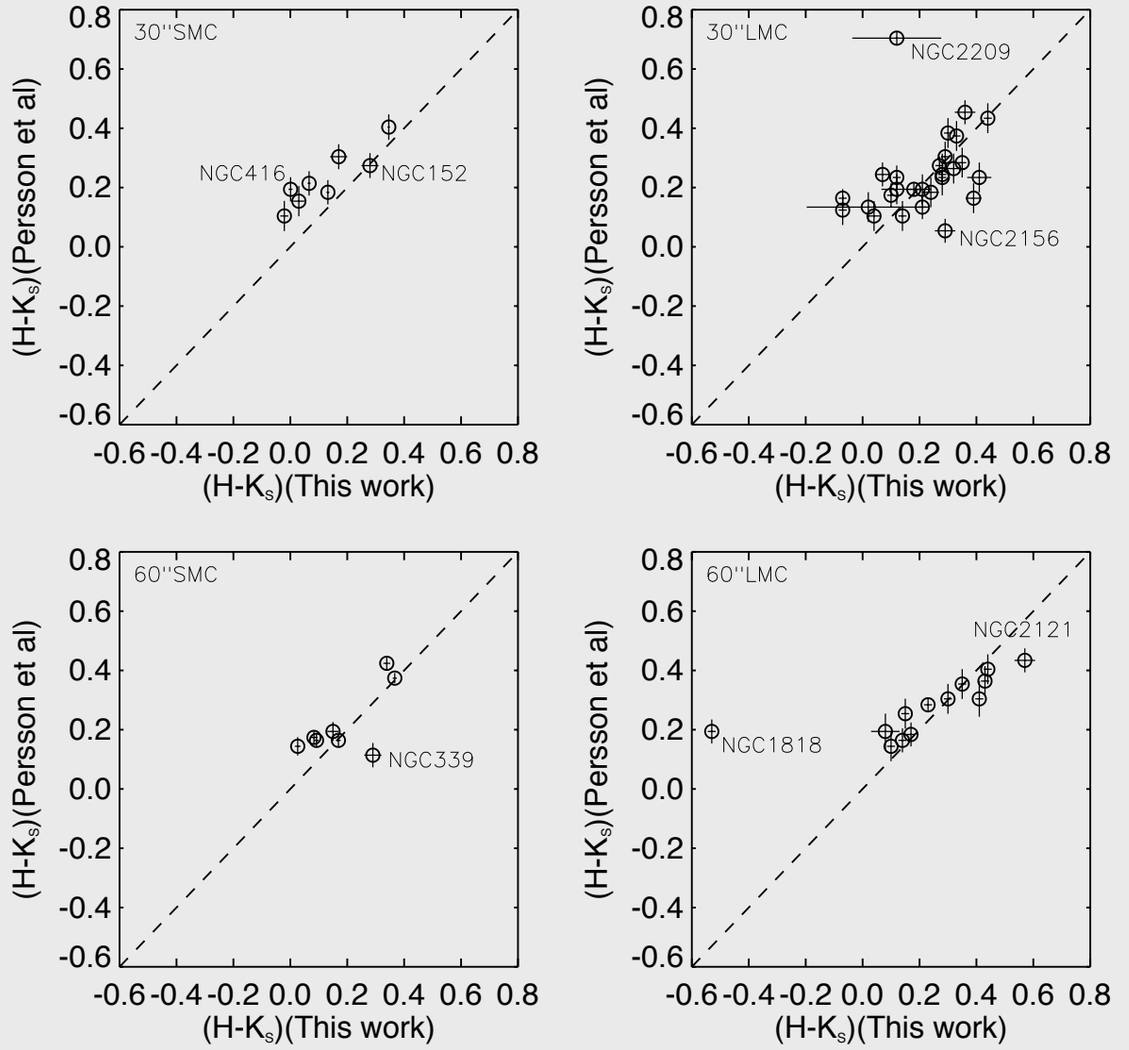






$(H-Ks)_{Persson}$ ver $(H-Ks)$

Comparison between our (H-Ks) colors and those, measured by a single-channel detector in 1983 for the SMC (left panels) and LMC clusters (right panels) in 30'' (up) and 60''(down) aperture diameter.

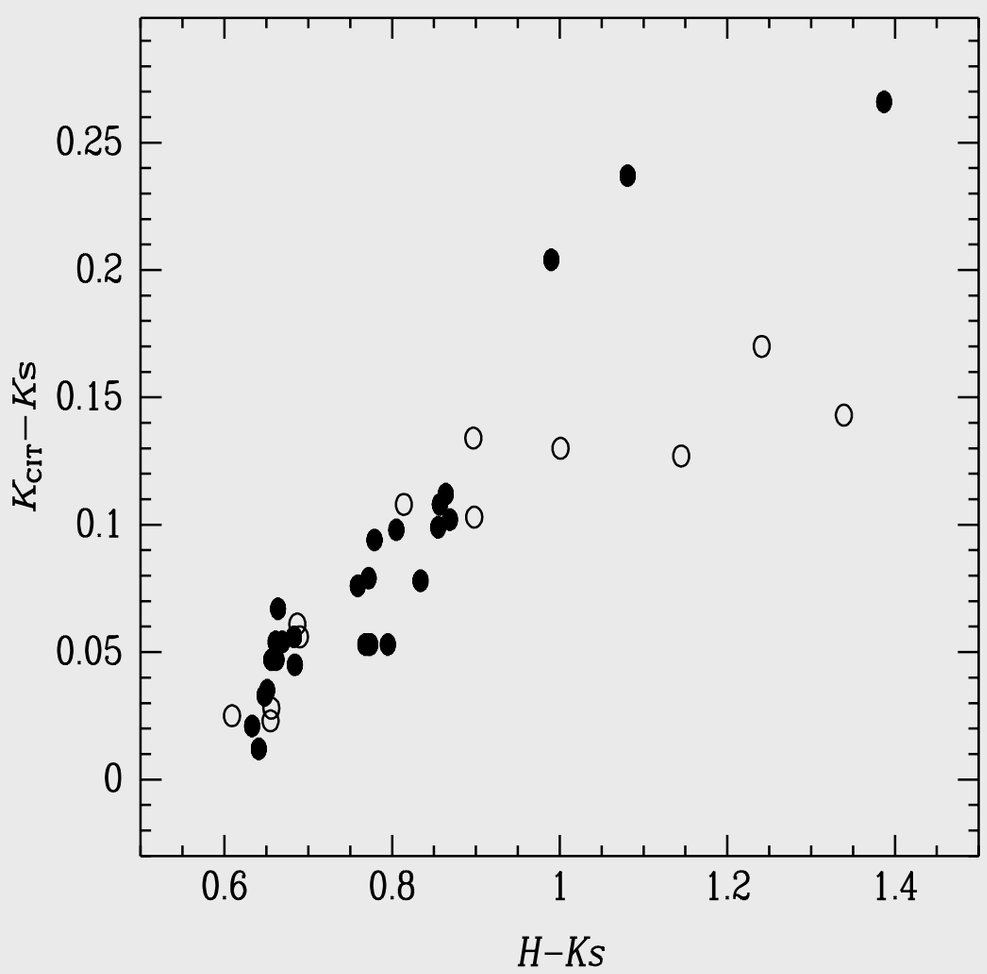


* due to the use of an iris diaphragm on the du Pont (2.5m) and CTIO (1m) telescopes at the time, some of the aperture diameters in Persson's study are known only to +/-1"

* in many cases the reproduced aperture positions of Persson et al. appear to cover the brightest part of the cluster

* the CO bands are affecting much more the K band, compared to Ks

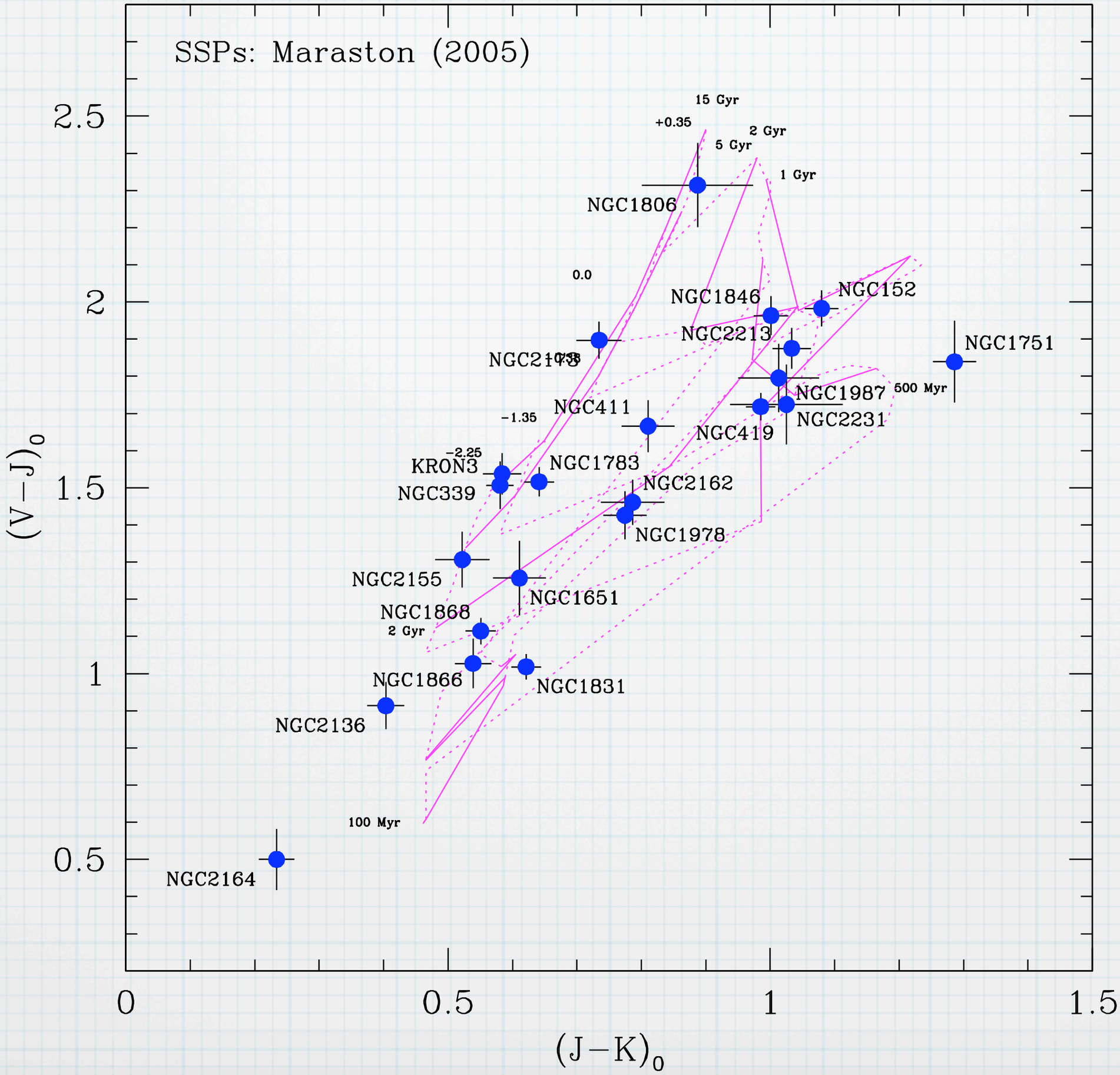
Relation between (H-Ks) and (K - Ks) for flux calibrated spectra of late type giant and supergiant stars. Filled symbols - data of G5III -M8III giants, open symbols - G2I - M7I supergiants. Note that the differences in the calibration from K to Ks become significant when (H-Ks) > 0.9

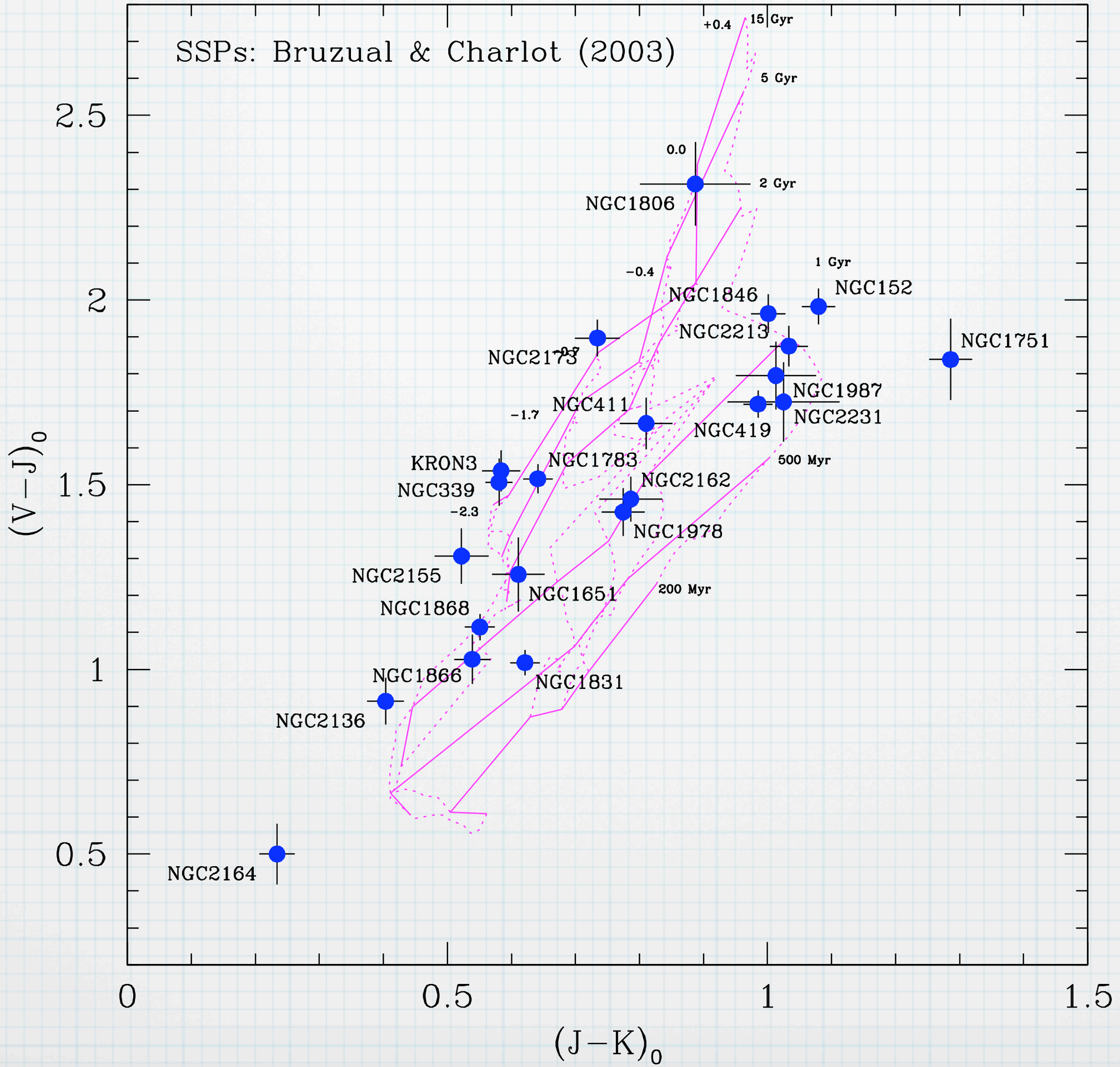


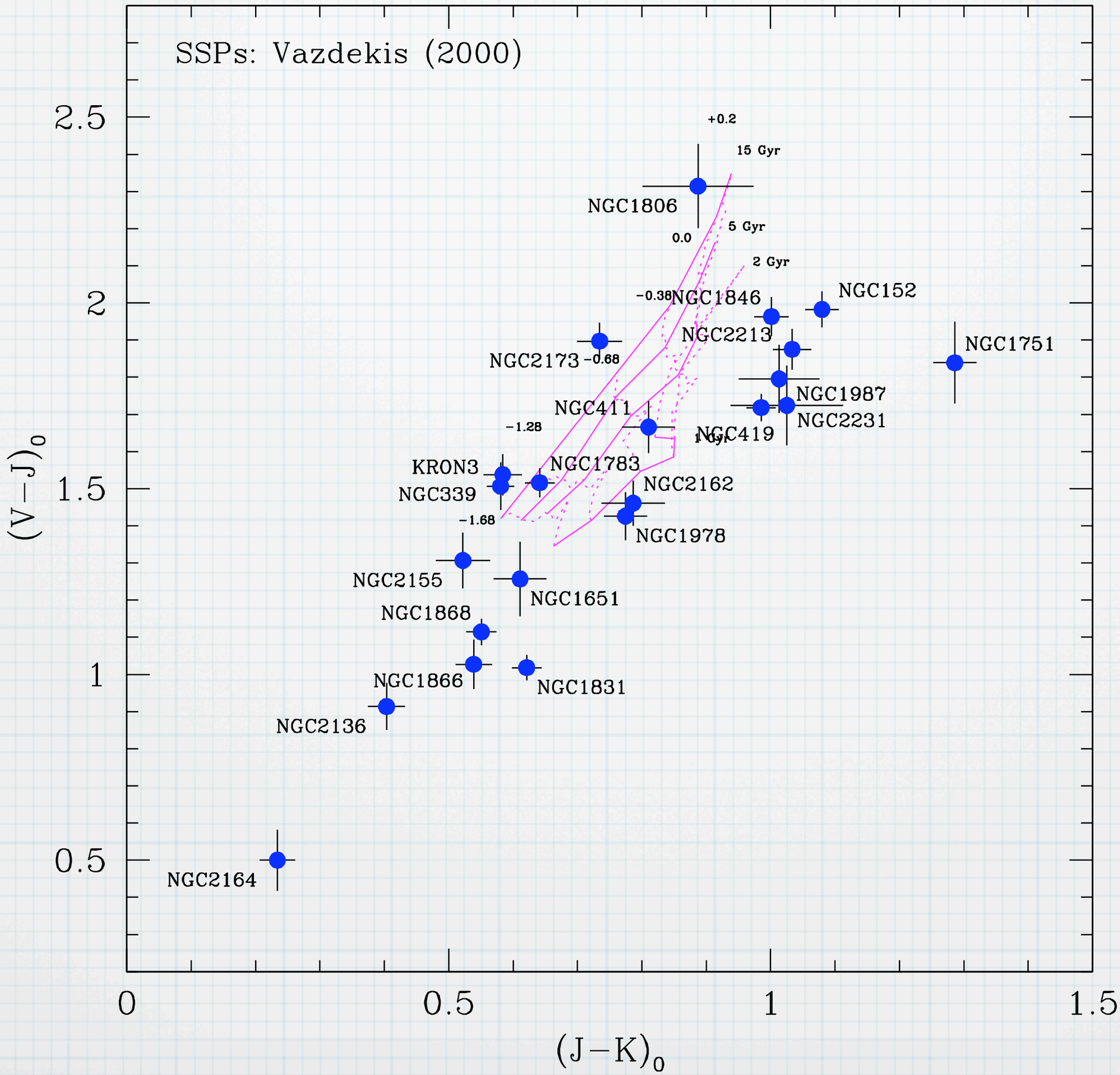
Comparison with recent SSP models

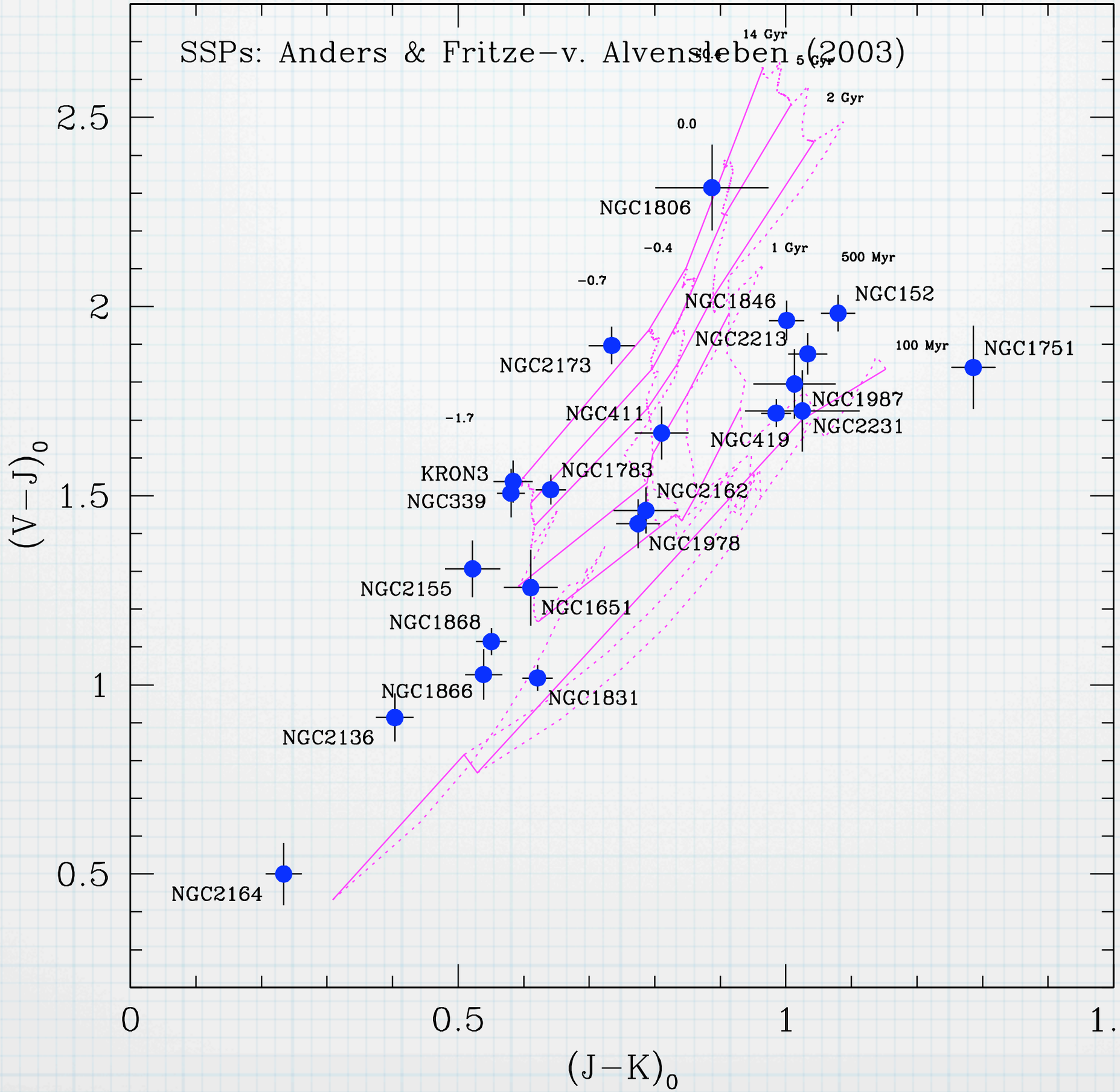
* The integrated V and NIR magnitudes are measured in the same aperture sizes (the V frames from the dataset of Goudfrooij et al.(2006) were used for the measurements)
* The cluster centers on the visual frames are derived, using a technique similar to that in the infrared.

* The magnitude values were corrected for the extinction, using the reddening estimators of the MCPS website: http://ngala.as.arizona.edu/dennis/lmcext.html http://ngala.as.arizona.edu/dennis/smcext.html
see Zaritsky et al. (2004) & Zaritsky et al.(2002) for details.


SSPs: Maraston (2005)
15 Gyr
+0.35
2 Gyr
5 Gyr
1 Gyr
NGC1806
0.0
NGC1846
NGC152
NGC2213
NGC1751
NGC2173
NGC1987
500 Myr
NGC411
-1.35
NGC2231
NGC419
-2.25
KRON3
NGC1783
NGC339
NGC2162
NGC1978
NGC2155
NGC1651
NGC1868
2 Gyr
NGC1866
NGC1831
NGC2136
100 Myr
NGC2164
2.5
2
1.5
1
0.5
0
0.5
1
1.5
(V−J)0
(J−K)0


SSPs: Bruzual & Charlot (2003)
+0.4
15 Gyr
5 Gyr
0.0
2 Gyr
-0.4
1 Gyr
-0.7
-1.7
500 Myr
-2.3
200 Myr
NGC1806
NGC1846
NGC152
NGC2213
NGC1751
NGC2173
NGC1987
NGC411
NGC2231
NGC419
KRON3
NGC1783
NGC339
NGC2162
NGC1978
NGC2155
NGC1651
NGC1868
NGC1866
NGC1831
NGC2136
NGC2164
2.5
2
1.5
1
0.5
0
0.5
1
1.5
(V−J)0
(J−K)0


SSPs: Vazdekis (2000)
+0.2
15 Gyr
NGC1806
5 Gyr
0.0
2 Gyr
-0.38
NGC1846
NGC152
NGC2213
NGC1751
NGC2173
-0.68
NGC1987
NGC411
NGC2231
-1.28
NGC419
1 Gyr
KRON3
NGC1783
NGC339
NGC2162
-1.68
NGC1978
NGC2155
NGC1651
NGC1868
NGC1866
NGC1831
NGC2136
NGC2164
2.5
2
1.5
1
0.5
0
0.5
1
1.5
$(V-J)_0$
$(J-K)_0$


SSPs: Anders & Fritze–v. Alvensleben (2003)
14 Gyr
5 Gyr
2 Gyr
1 Gyr
500 Myr
100 Myr
0.0
−0.4
−0.7
−1.7
NGC1806
NGC1846
NGC152
NGC2213
NGC1751
NGC2173
NGC1987
NGC411
NGC2231
NGC419
KRON3
NGC1783
NGC339
NGC2162
NGC1978
NGC2155
NGC1651
NGC1868
NGC1866
NGC1831
NGC2136
NGC2164
2.5
2
1.5
1
0.5
0
0.5
1
1.5
$(V-J)_0$
$(J-K)_0$

Overview and Conclusions

* We present a new database of integrated magnitudes and colors for a sample of LMC and SMC star cluster, covering a wide range of ages and metallicities, taking advantage of the highly uniform as spatial coverage and photometric calibration 2MASS database. Our results can be used for improving of the now available and upcoming SSP models

Future Plans

* We are going to extend the measurements of the total magnitudes and colors of SSP in the mid-IR part of the spectrum, using Spitzer IRAC data for a sample of GCs in our Galaxy and Magellanic Clouds.

Thank You!