

## ABSTRACT

We present an astrometric catalogue of positions and proper motions derived from the *Carte du Ciel* plates of the San Fernando zone, photographic material with a mean epoch 1901.4.

Digitization has been made using a conventional flatbed scanner. Special techniques have been developed to handle the large distortion introduced by the scanner. The equatorial coordinates are on the ICRS defined by Tycho-2 and proper motions are derived using UCAC2 as second-epoch positions. The mean positional uncertainty is 0.2" and the proper-motion uncertainty is 2.0 mas/yr.

The proper motion catalogue CdC-SF is effectively a deeper extension of Hipparcos, in terms of proper motions, to magnitude 15.

## CARTE DU CIEL PLATES

The historic plates of the *Carte du Ciel*, an international cooperative project launched in 1887, offer valuable first-epoch material for the determination of absolute proper motions.

The plate material used corresponds to the collection stored in the Real Instituto y Observatorio de la Armada in San Fernando (Spain), which was charged with observing the area between  $\delta = (-10^\circ, -2^\circ)$ . This collection of 1260 plates has not been exploited up to now.

Each plate covers a field of  $2^\circ \times 2^\circ$  and observations were planned in a full overlapping strategy. Plates along odd declinations were exposed three times, producing a pattern of images for each star that is an equilateral triangle. All of the plates also contain a superposed *réseau* grid lines.

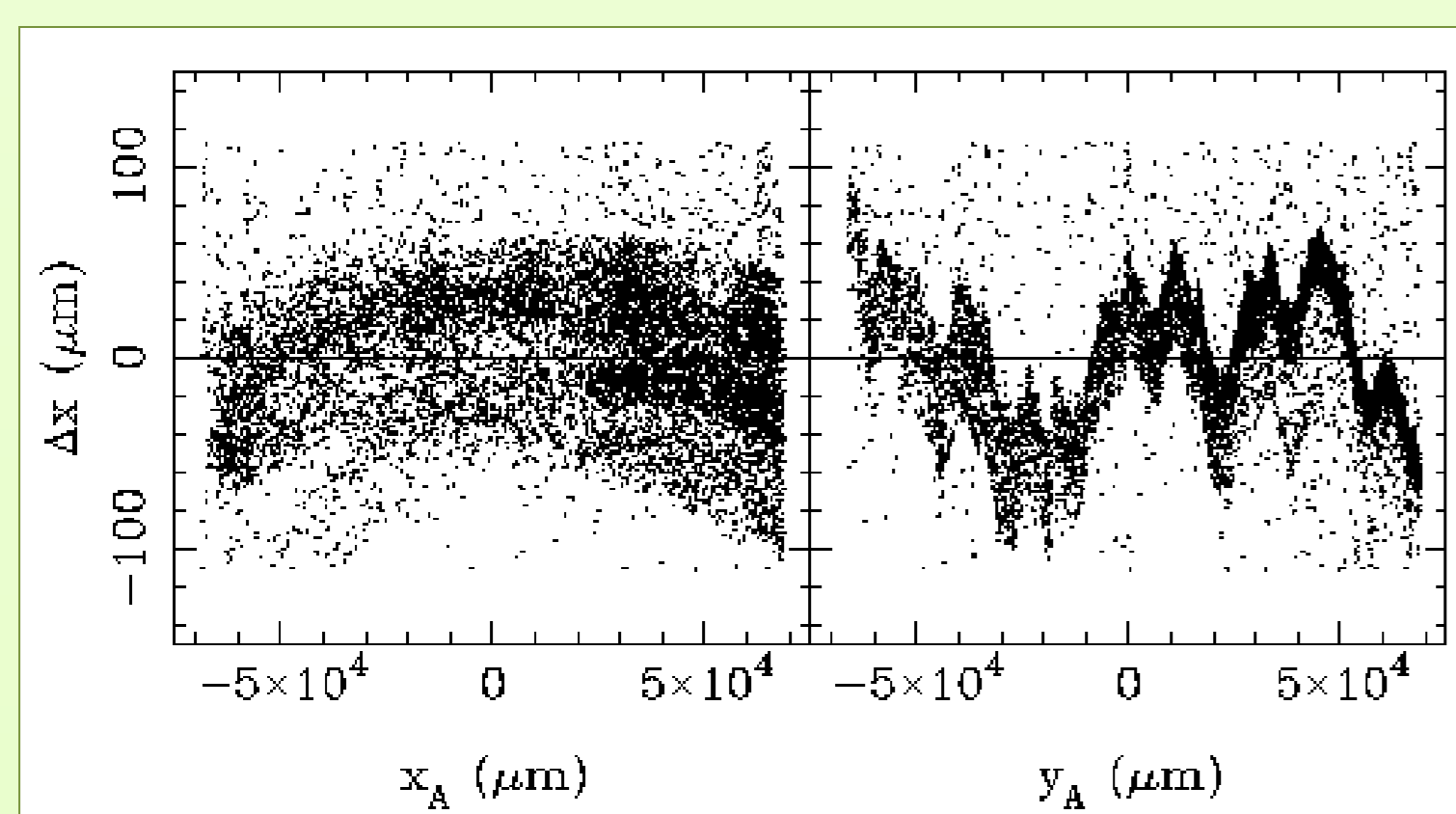
## ASTROMETRIC REDUCTION

Digitization has been made using the commercial flatbed scanner Agfa DuoScan f40. It has been developed a method of removing the mechanical distortion introduced (Fig.1). A final measuring accuracy of 0.2" is achieved, similar to what has been obtained in other studies using specialized measuring machines (Rapaport et al. 2006).

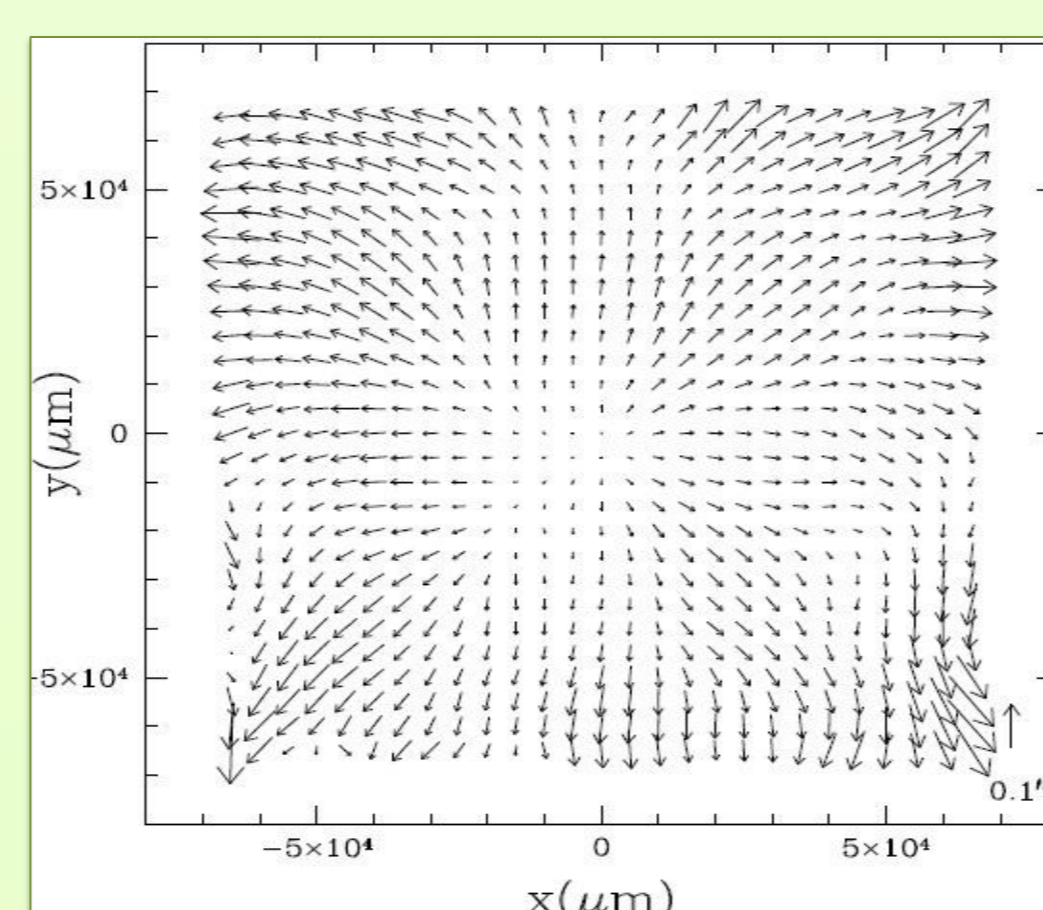
The final measures are reduced to celestial coordinates using a block-adjustment technique (Stock 1991). The Tycho-2 Catalogue (Høg et al. 2000) was used as reference, 2MASS infrared photometry (Cutri et al. 2003) is also included.

The early-epoch CdC positions are combined with UCAC2 catalogue (Zacharias et al 2008) to derived proper motions. They are placed on the ICRS system via a direct comparison to Hipparcos proper motions, applying a local correction for systematic effects.

More details in Vicente et al (2007) and Vicente et al. (2009)

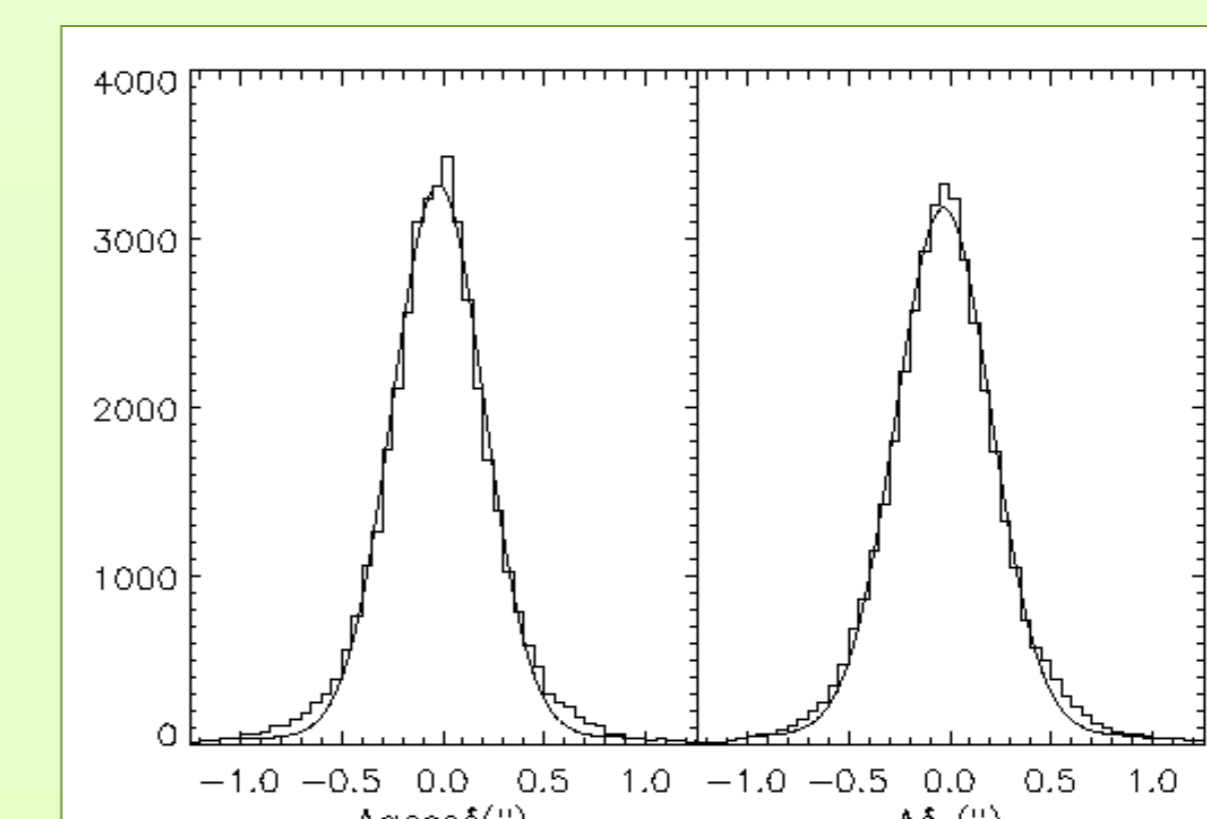
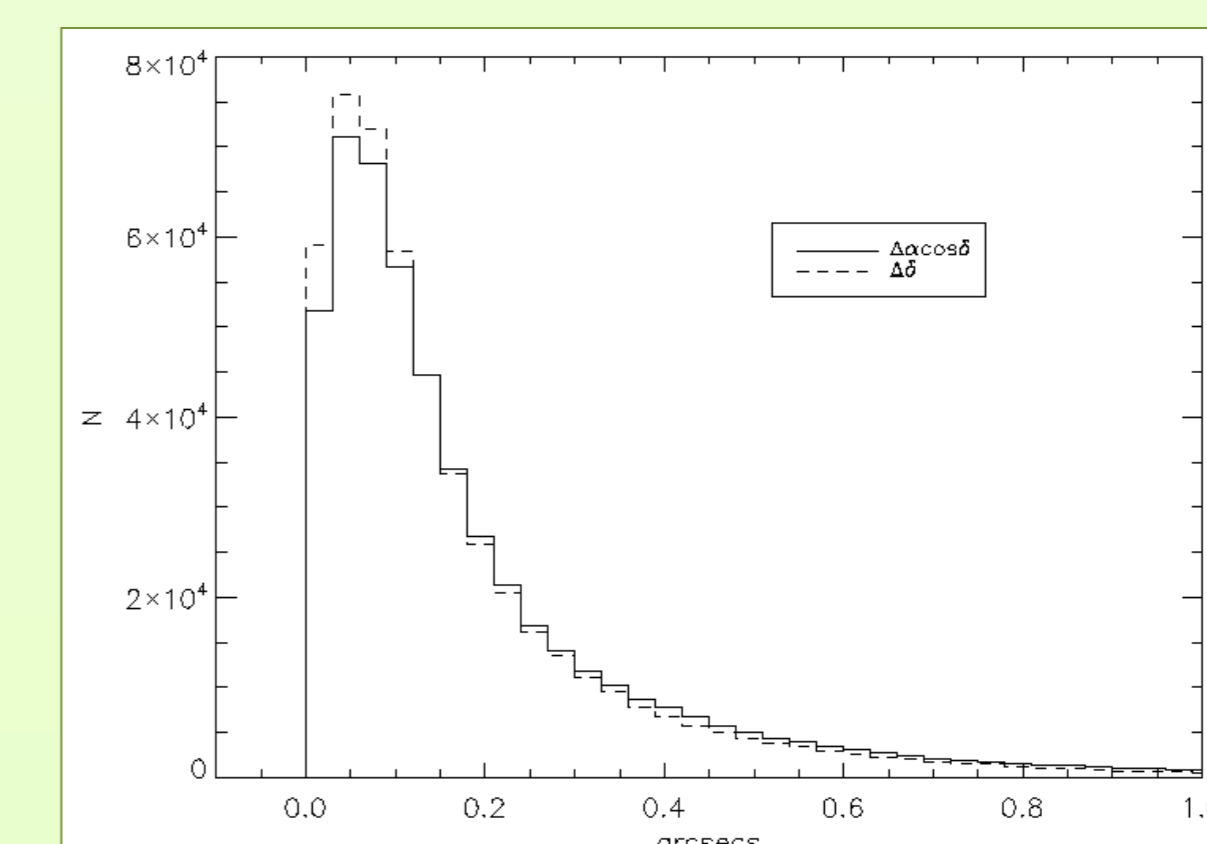
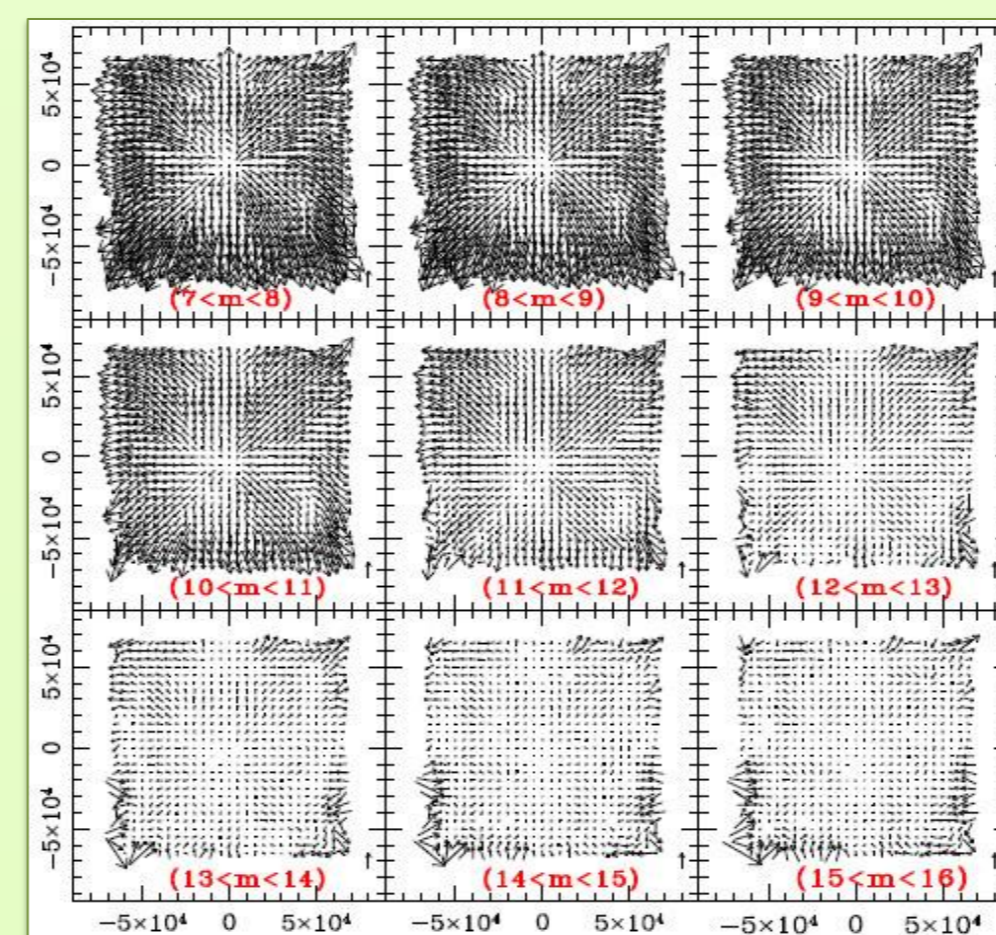


**Fig. 1** Positional differences obtained from two digitalizations of the same plate, rotated one with regard to other by 90°. Notice that the amplitude in the errors in the Y axis is considerable. In addition, this distortion varies from scan to scan and from plate to plate.



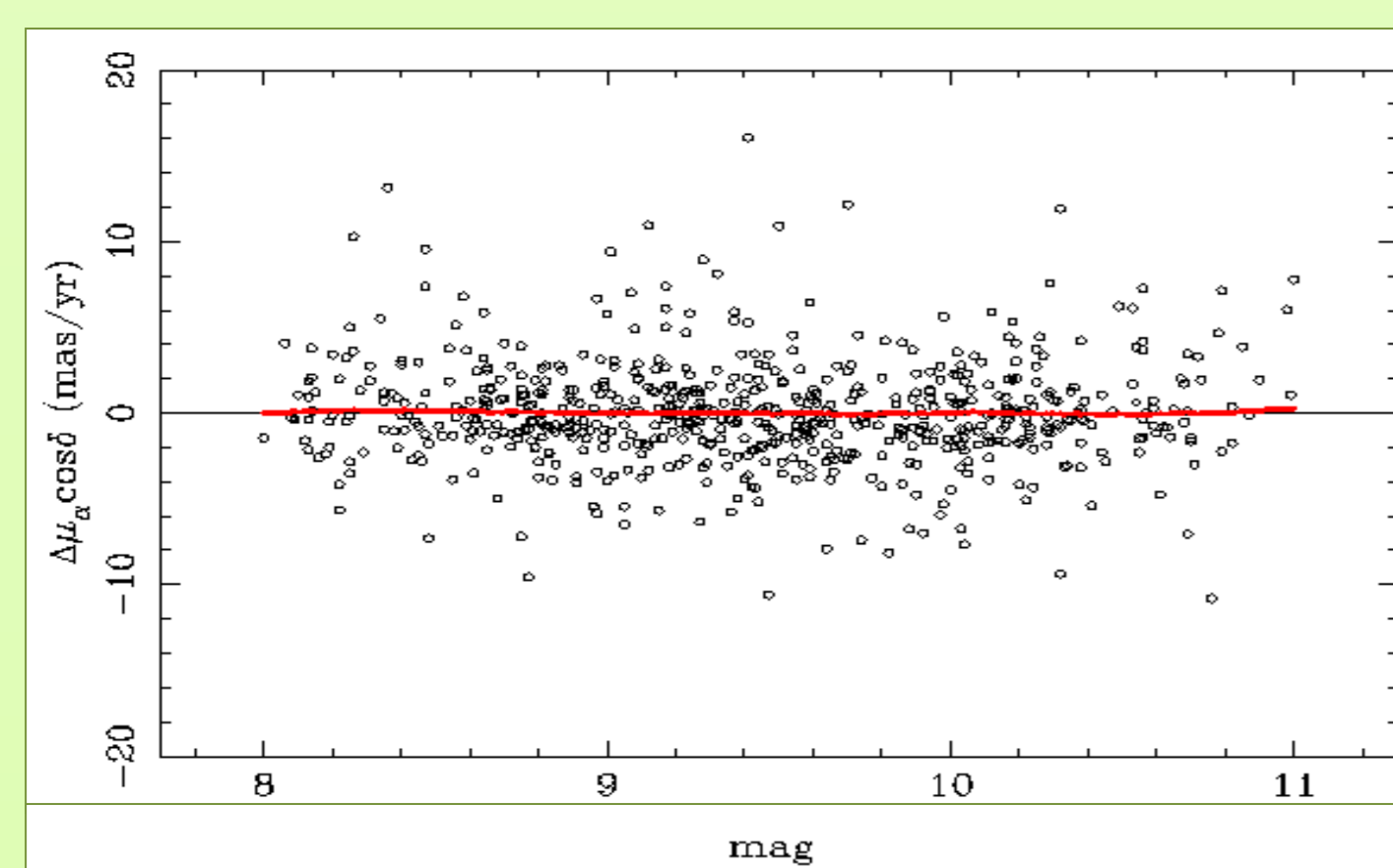
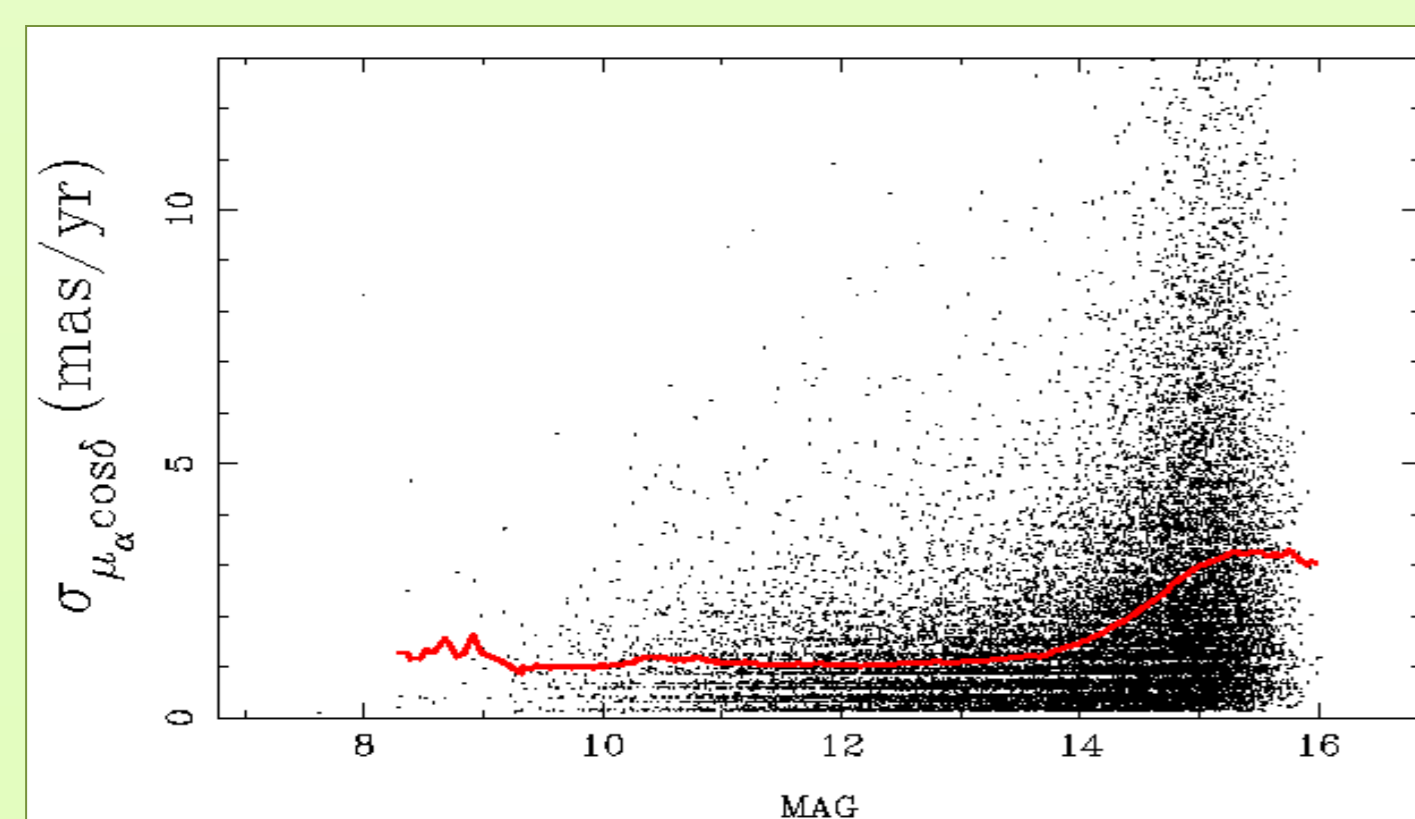
**Fig. 2 (a)** Position residual as a function of coordinates after linear plate model is applied, showing the systematic errors in the plates due to telescope optics.

**Fig. 2 (b)** Vector residuals plotted for different magnitude ranges. Positions within a given magnitude range are corrected using the appropriated mask. In this way, magnitude-equation is removed.



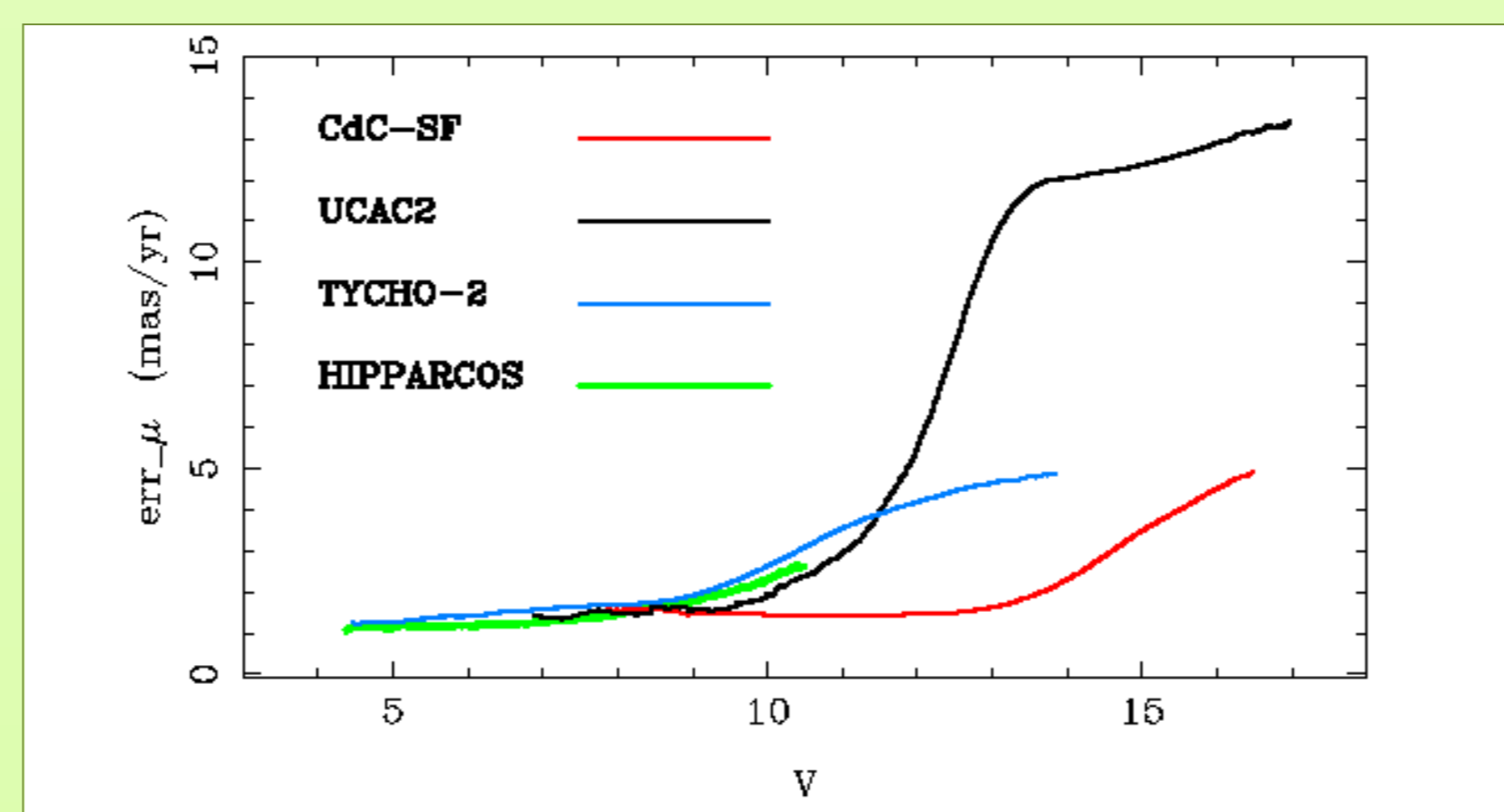
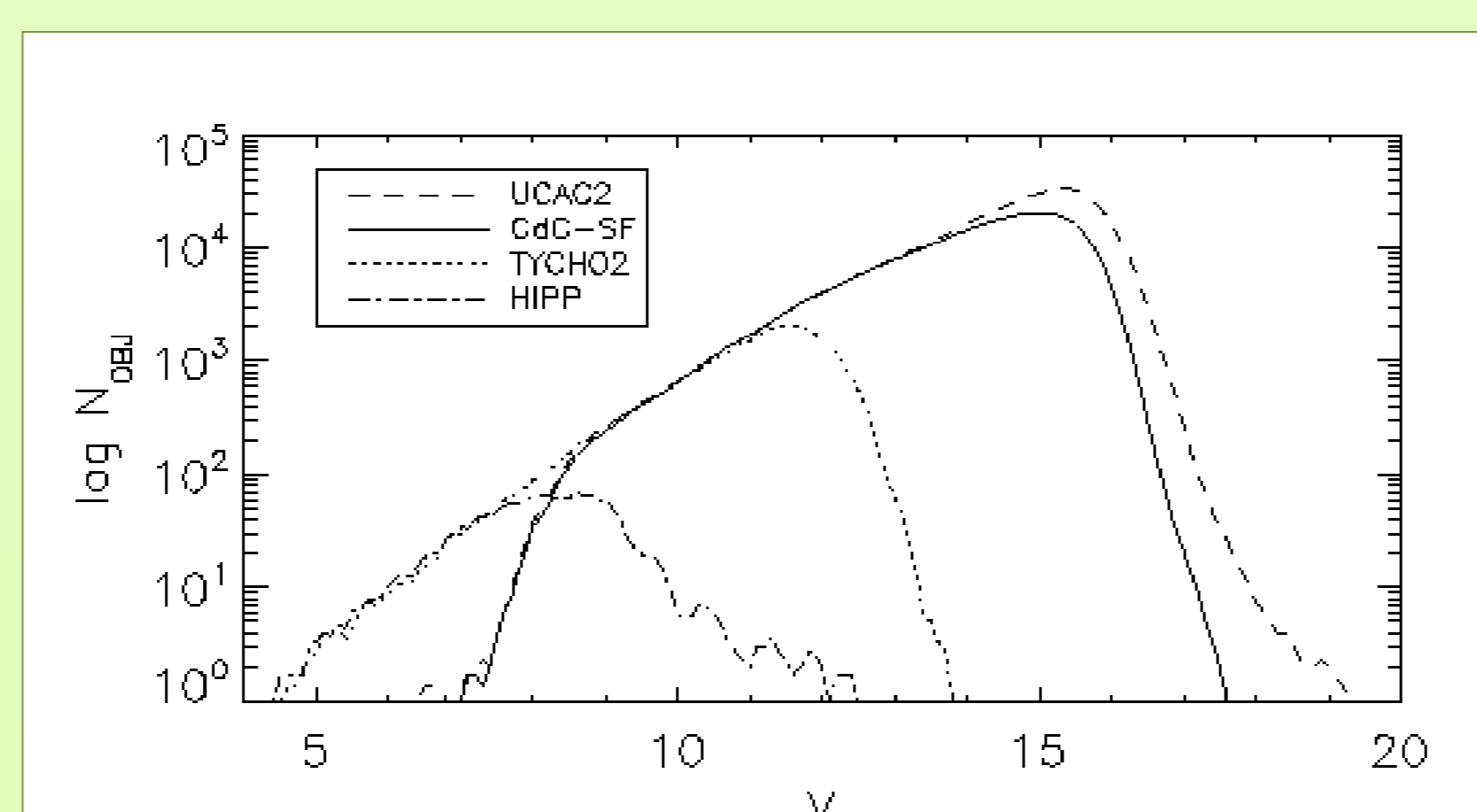
**Fig. 3 (a)** Histogram of the internal uncertainties, estimated from the rms of the positional differences of overlapping images.

**(b)** Differences of CdC-SF positions and Tycho-2 positions, at the epoch of the plates. We obtain a well defined Gaussian distributions which standard deviation are  $\sigma_{\alpha \cos \delta} = 0.22''$  and  $\sigma_{\delta} = 0.24''$ .



**Fig. 4 (a)** Proper-motion uncertainties as a function of magnitude obtained from the quadrature sum of the stated positional uncertainties in the catalogue CdC-SF and in the UCAC2 divided by the epoch difference.

**(b)** Differences of CdC-SF proper motion compared with Hipparcos as a function of magnitude. In both, the red line indicates a moving-mean, the other coordinate shows similar behaviour.



**Fig. 5** Magnitude distribution and moving-average error of proper motions, as function of magnitude of the CdC-SF catalogue compared to other astrometric catalogues.

## CdC-SF CATALOGUE SUMMARY

Mean epoch	1901.4, ICRS
Area covered	~1080 degrees <sup>2</sup>
Position range	$06^h \leq \alpha \leq 14^h, -10.5^\circ \leq \delta \leq -2.5^\circ$
Magnitude range	$6 \leq V \leq 16.3$
Completeness	$V \sim 15.1$
Measuring error	$3 \mu\text{m} \sim 0.18''$
Position error	$\sigma_{\text{pos}} = (0.12'', 0.11'')$ for $V < 14$ $\sigma_{\text{pos}} = (0.21'', 0.19'')$ for $V < 16$
Proper motion error	$\sigma_{\mu} = (1.2, 1.1) \text{ mas/yr}$ for $V < 14$ $\sigma_{\mu} = (2.0, 1.9) \text{ mas/yr}$ for $V < 16$

## REFERENCES

- Skrutskie, M., Cutri, R., Stiening, R., et al. 2006, AJ 131, 1163
- Høg, E., Fabricius, C., Makarov, V., et al. 2000, A&A 357, 367
- Rapaport, M., Ducourant, C., Le Campion, J. et al. 2006, A&A 449, 435
- Stock, J. 1981, RMxAA 6, 115
- Vicente, B., Abad, C. & Garzón, F. 2007, A&A 471, 1077
- Vicente, B., Abad, C., Garzón, F. & Girard, T. 2009, A&A accepted
- Zacharias, N., Urban, S., Zacharias, M., et al. 2004, AJ 127, 3043