RevMexAA (Serie de Conferencias), **46**, 79–80 (2015)

UNCERTAINTIES OF ASTROMETRIC CATALOGUES SPM_{MC}, XPM AND $UCAC4$ IN THE MAGELLANIC CLOUDS USING THE WIELEN METHOD

Eddy Dávila[1,2] and Katherine Vieira[2]

RESUMEN

Se determina la incertidumbre individual de los catálogos de movimientos propios SPM_{MC}, XPM y $UCAC4$ mediante el uso del método de Wielen, en un área del cielo que contiene a las Nubes de Magallanes. Estas incertidumbres son una medida de la calidad de estos catálogos para estudios cinemáticos. La preparación de los datos comienza por la identificación cruzada de estrellas comunes a los catálogos y, sobre esta muestra se detectan, modelan y corrigen las diferencias sistemáticas entre ellos. Una vez aplicado el método de Wielen y evaluados los resultados obtenidos, se concluye que el catálogo de mejor calidad astrométrica es $UCAC4$, con una incertidumbre de $(\epsilon_{\mu_\alpha cos(\delta)}, \epsilon_{\mu_\delta})$=(2.92,1.90) *msa/año*. El SPM_{MC} posee una calidad similar a la del catálogo anterior, su incertidumbre se expresa como $(\epsilon_{\mu_\alpha cos(\delta)}, \epsilon_{\mu_\delta})\frac{SPM_{MC}}{UCAC4}$=(1.11,1.53) *veces* la de $UCAC4$. Finalmente la calidad de XPM difiere significativamente de las correspondientes a los catálogos anteriores, ésta resulta ser $(\epsilon_{\mu_\alpha cos(\delta)}, \epsilon_{\mu_\delta})\frac{XPM}{UCAC4}$=(6.32,8.87) *veces* la de $UCAC4$.

ABSTRACT

The individual uncertainties of the proper motion catalogues SPM_{MC}, XPM and $UCAC4$ are determined using the method of Wielen, in an area of the sky containing the Magellanic Clouds. These uncertainties are a measure of the quality and the reliability of these catalogs for kinematical studies. The data preparation begins by cross identifying stars common to the catalogs, and on this sample, systematic differences are detected, modeled and corrected. After applying the Wielen method and evaluating the results, it follows that the catalog of best astrometric quality is $UCAC4$, with an uncertainty of $(\epsilon_{\mu_\alpha cos(\delta)}, \epsilon_{\mu_\delta})$=(2.92,1.90) *mas/yr*. The SPM_{MC} has a quality similar to the previous catalogue, expressed as $(\epsilon_{\mu_\alpha cos(\delta)}, \epsilon_{\mu_\delta})\frac{SPM_{MC}}{UCAC4}$=(1.11,1.53) *times* the $UCAC4$. Finally the quality for the XPM differs significantly from the other two catalogues, its errors are $(\epsilon_{\mu_\alpha cos(\delta)}, \epsilon_{\mu_\delta})\frac{XPM}{UCAC4}$=(6.32,8.87) *times* the UCAC4.

Key Words: astrometry — catalogs — proper motion — reference systems

1. INTRODUCTION

The quality of a proper motion catalogue is determined by its precision and most importantly, its accuracy. The repeatability of the measurements is the definition - and measurement - of precision, unfortunately this error estimation is in many cases quoted as a measure of the quality of the catalogue, without giving any information as to the accuracy of the reference frame realized by the catalog. This critical piece of information tells us how close the catalog is to the International Celestial Reference System (ICRS) and it is indeed the hardest quantity to estimate, as it must evaluate the catalogue data against a set of reference values taken or known as true, which are not always available.

Generally, error estimation in a catalogue is made by comparing it to another one whose errors are well known. Any systematic difference that exists between them, will reveal the inaccuracy of the catalog being studied with respect to the comparison catalog. If those differences are corrected, then it is expected that this new version will only have the inaccuracy of the reference catalog to which is being compared (assuming that the correction itself does not contribute a significant error). Once this is done, the dispersion of the differences between the data in both catalogs will measure the internal precision of both catalogs, and the precision of the catalog being studied can be found. Any incorrect estimation of the errors in the reference catalog will bias the error estimation in the catalog under investigation. A way to overcome this limitation is to have three or more catalogs, and a simultaneous comparison between them avoids this problem, allowing the computation of the precision of each catalog without assuming any apriori error estimation. The procedure involved is called the Wielen method (Wielen, R. 1995).

[1]Universidad del Zulia (LUZ), Apartado Postal 526, 4011, Maracaibo, Venezuela.

[2]Centro de Investigaciones de Astronomía (CIDA), Apartado Postal 264, 5101-A, Mérida, Venezuela.

In this work we apply the Wielen method to the proper motion catalogues SPM_{MC} (Southern Proper Motion in the Magellanic Clouds)(Vieira, K. et al. 2010), XPM(Fedorov, P.N. et al. 2009) and $UCAC4$ (The Fourth U.S. Naval Observatory CCD Astrograph Catalog) (Zacharias, N. et al. 2013), to estimate their uncertainties in a extended zone of the sky that encloses the Magellanic Clouds. These are the most extended and deep catalogs in the area and their proper motions could be applied to valuable kinematical studies in the Local Group, if their data were indeed good enough for such a task.

2. APPLYING THE WIELEN METHOD

The first step is to make a cross identification between the three catalogues, to obtain a common sample of data. According to the authors, all three catalogs have positions and proper motions in the same reference system, the ICRS, and at the same epoch, 2000.0. Under this circumstance, the average of the data differences between them should be zero. This does not happen frequently, generally systematic differences exist between catalogs, which will vary depending on sky position, magnitude and even color. Such differences in most cases can be traced back to systematic problems in the telescope or the detector (e.g. optical distortions), which translate finally into biased reference frames. Wielen's method requires such differences to be corrected in advance. We chose the SPM_{MC} as the standard catalog against which we correct for systematic differences, as it has been successfully used in the determination of the proper motion of the Magellanic Clouds by Vieira, K. et al. (2010), therefore we believe it is a trusted realization of the ICRS.

We detected, modeled and corrected for systematic differences in position and proper motions, depending on sky coordinates α and δ, magnitude J and color $J-K$. The differences depending on position were modeled using a moving average, weighted by angular distance θ such that closer stars had a higher weight given by $\left(\sqrt{\left(1-\left(\frac{\theta_i}{\theta_{lim}}\right)^2\right)}\right)^3$. The differences versus magnitude and color were modeled with polynomials.

3. RESULTS

The Wielen method can be applied to two independent catalogs, from which a third one is created using the positions at mean epoch in each catalog. We applied this version of the method to SPM_{MC} y XPM, but we found incoherent results, negative uncertainties for SPM_{MC}, which turned out to be caused by the significantly larger errors of the XPM and also the small time difference between the mean epochs of both catalogues. We then added a third catalog, $UCAC4$, to have a more appropriate set of proper motions on which the Wielen method might work. The method is highly sensitive to the quality of the catalogs being compared, if one catalog is noticeable worse than the other, then a catalog created from those will also be of poor quality and the method tends to fail. With a third independent high quality catalog the method has a better chance of succeeding.

$UCAC4$ is not entirely independent, since $SPM4$ and $UCAC4$ use the same 1st-epoch photographic plates and any comparison between them will underestimate their errors. Therefore to apply Wielen's method properly we estimated the effect of their correlation, by including the corresponding covariance term in the equations. In Figure 1, we plot our results of the individual uncertainties for each of the three mentioned catalogs. For the brightest magnitudes the method failed, presumable due to large errors in the XPM and small number statistics. For magnitudes $J > 7$, the uncertainties stabilize for SPM_{MC} and $UCAC4$ below 5 *mas/yr*, while for the XPM they change with magnitude and are noticeably larger.

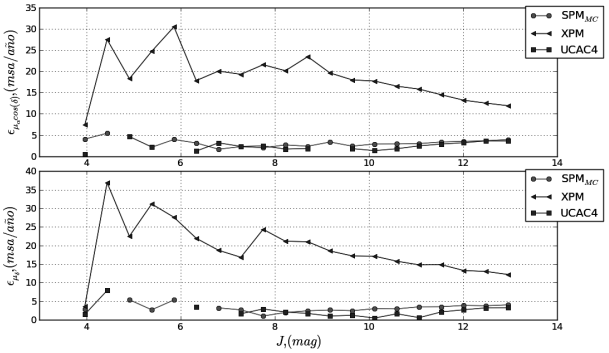

Fig. 1. *Individual uncertainties of the proper motion catalogs SPM_{MC}, XPM and $UCAC4$, estimated using Wielens method.*

REFERENCES

Fedorov, P.N., et al. 2009, MNRAS 393, 133
Monet, D.G., 1998, BAAS 30, 1427
Skrutskie, M.F., et al. 2006, AJ 131, 1163
Vieira, K., et al., 2010, AJ 140, 1934
Wielen, R., 1995, A&A 302, 613
Zacharias, N., et al., 2013, AJ 145, 44