

OBSERVATIONAL CATALOGUES OF DOUBLE STAR POSITIONS
(1980-1987) AND THEIR PROPERTIES

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SUMMARY: This work deals with the systematic differences $\Delta\alpha$ and $\Delta\delta$ of observational catalogues of the DS programme stars made between 1980-1987. These differences are examined through the comparison with the preliminary derived mean system. By applying the Whittaker-Robinson-Vondrak method of smoothing observational data, the elimination of the discovered systematic influences of type $\Delta\delta$ in three catalogues is performed.

1. INTRODUCTION

Between 1980-1987 seven observational catalogues of the DS programme star positions were made Belgrade (Sadžakov and Dačić, 1990), Kiev (Чернега et al., 1987), Kharkov (Павленко, 1989), Odessa (Мялковский, 1988), Moscow 1 (Таубер, 1986), Moscow 2 (Головко, 1982) and Kazan (Яценко, 1989). This programme was proposed by IAU in 1958 and 1979. The observations were made with the meridian circles and the results obtained by the

relative method. The positions of the stars in the catalogues are given in the FK4 system for the equinox B1950.0 and the observational epoch. The characteristics of the observational catalogues are given in Table 1.

Table 1 shows that the catalogues stated deal with a considerably different number of stars covering different declination zones. For the catalogue comparison stars with the coordinates found in at least two catalogues have been singled out (N_α and N_δ in Table 1).

Table 1. Characteristics of the observational catalogues

catalogue	per.ob.	coord.	N	$\epsilon_\alpha \cos\delta$	ϵ_δ	dec. zone	N_α	N_δ
Belgrade	1981-87	α, δ	1571	$\pm 0''.026$	$\pm 0''.34$	$-30^\circ - +60^\circ$	922	1173
Kiev	1980-84	α, δ	986	$\pm 0''.027$	$\pm 0''.46$	$+10^\circ - +90^\circ$	929	974
Kharkov	1980-84	$\alpha, -$	240	$\pm 0''.024$	-	$+50^\circ - +70^\circ$	239	-
Odessa	1983-85	$-, \delta$	250	-	$\pm 0''.38$	$-10^\circ - +10^\circ$	-	243
Moscow 1	1981-83	$-, \delta$	313	-	$\pm 0''.30$	$0^\circ - +90^\circ$	-	309
Moscow 2	1981-82	$-, \delta$	319	-	$\pm 0''.33$	$0^\circ - +90^\circ$	-	316
Kazan	1981-87	$-, \delta$	644	-	$\pm 0''.45$	$+30^\circ - +90^\circ$	-	641

The last visual observations of double stars of this programme were made by L. Courvoisier in the thirties and the stars themselves do not have strictly determined proper motions. Exact determination of their positions and proper motions was the ultimate aim of the DS programme. Bearing this in mind systematic differences of the observational catalogues were examined on the basis of comparison with the preliminary derived mean system. Proper motions given in the basic list of DS programme stars, have been used for reduction to the observational epoch. The coordinate errors caused by such proper motions are negligible in a short interval covering all observational epochs of 7 years or less. For this period the influence of orbital motion is also negligible, because the orbital motion periods of the observed components of binaries are extremely large - tens, hundreds and even thousands of years.

2. SYSTEMATIC DIFFERENCES AND THEIR DISCUSSION

The right ascension, declination and epoch mean values are computed, for each star, using the following formulae:

$$\alpha_s = \frac{1}{2} \sum_{i=1}^n \alpha_i, \quad \delta_s = \frac{1}{2} \sum_{i=1}^n \delta_i, \quad t_s = \frac{1}{2} \sum_{i=1}^n t_i \quad (1)$$

where n has the value of 2 or 3 for right ascension and 2,3,4 or 5 for declination. All stars are given the same weight $p=1$. When computing the differences between catalogue coordinates and the mean system, α_s and δ_s have been reduced to the observational epoch of a star of the particular catalogue according to the formula:

$$\Delta\alpha_i = \alpha_i - \alpha_s - \mu_\alpha(t_i - t_s),$$

$$\Delta\delta_i = \delta_i - \delta_s - \mu_\delta(t_i - t_s) \quad (2)$$

The differences arrived at by formula (2) for all catalogues are given in Figs.1-9, in relation to right ascension (α), declination (δ), magnitude (m) and spectral type (Sp). For the discovery of systematic errors the Abbe criterion was used, showing (see Tables 2 and 3) that only systematic influences of the type $\Delta\delta_s$ exist in both Moscow catalogues and in the Kazan catalogue as well. It can be confirmed considering Figs.1-9. It is fully obvious that the Moscow catalogues curves $\Delta\delta_s$ (Figs. 7b and 8b) are almost identical. As they were made with the same instrument, we can conclude that the instrument system influences are not excluded. By comparing the curves $\Delta\delta_s$ on the Figs. 7b and 8b with those of the declination instrument system of the Moscow meridian circle (Головко, 1982) and (Тайбер, 1986), one can

notice their opposite direction with their maximum and minimum values being of the same declination.

Explanation for the systematic influence $\Delta\delta_s$ does not exist in the case of the Kazan catalogue. The author of this catalogue himself quotes three items to which attention should be paid in future work. First, in processing the material the limb division correction was used determined when the circle was read by visual microscope. Second, it is possible for the electric motor rewinding the film to move it by a certain angle, and the read out is not in the plane normal to the dotted line. And third, frequent and irregular changes of the temperature used for the refraction computation have been noticed in the north part of the pavilion. All this could be the cause of the systematic deviation $\Delta\delta_s$ present in the Kazan catalogue, but it should have appeared during the instrument system derivation. However, the corrections given for this instrument system were small and not taken into account during the reduction of material.

Therefore, the following assumption seems possible: systematic influences $\Delta\delta_s$ in the Moscow catalogues (included in the mean system) could have been reproduced only in the appearance of systematic influences of the same type in the Kazan catalogue. In other catalogues such an influence could not appear: in the Odessa catalogue due to a small number of common stars (only 11), in the Belgrade and the Kiev catalogues the number of stars is 3-4 times more, therefore the systematic errors of the Moscow catalogues have been subdued. However, as we shall see later on, this assumption is wrong.

Table 2. Results of Abbe criterion for catalogues containing right ascension for all types of dependence.

catalogue	type	$\gamma(n)$	$\gamma'(n)$	n
Belgrade	$\Delta\alpha_\alpha$	0.953	0.946	922
	$\Delta\alpha_\delta$	0.994		
	$\Delta\alpha_m$	0.977		
	$\Delta\alpha_{sp}$	0.998		
Kiev	$\Delta\alpha_\alpha$	0.957	0.946	929
	$\Delta\alpha_\delta$	0.989		
	$\Delta\alpha_m$	0.959		
	$\Delta\alpha_{sp}$	0.972		
Kharkov	$\Delta\alpha_\alpha$	0.987	0.894	239
	$\Delta\alpha_\delta$	0.934		
	$\Delta\alpha_m$	1.046		
	$\Delta\alpha_{sp}$	1.047		

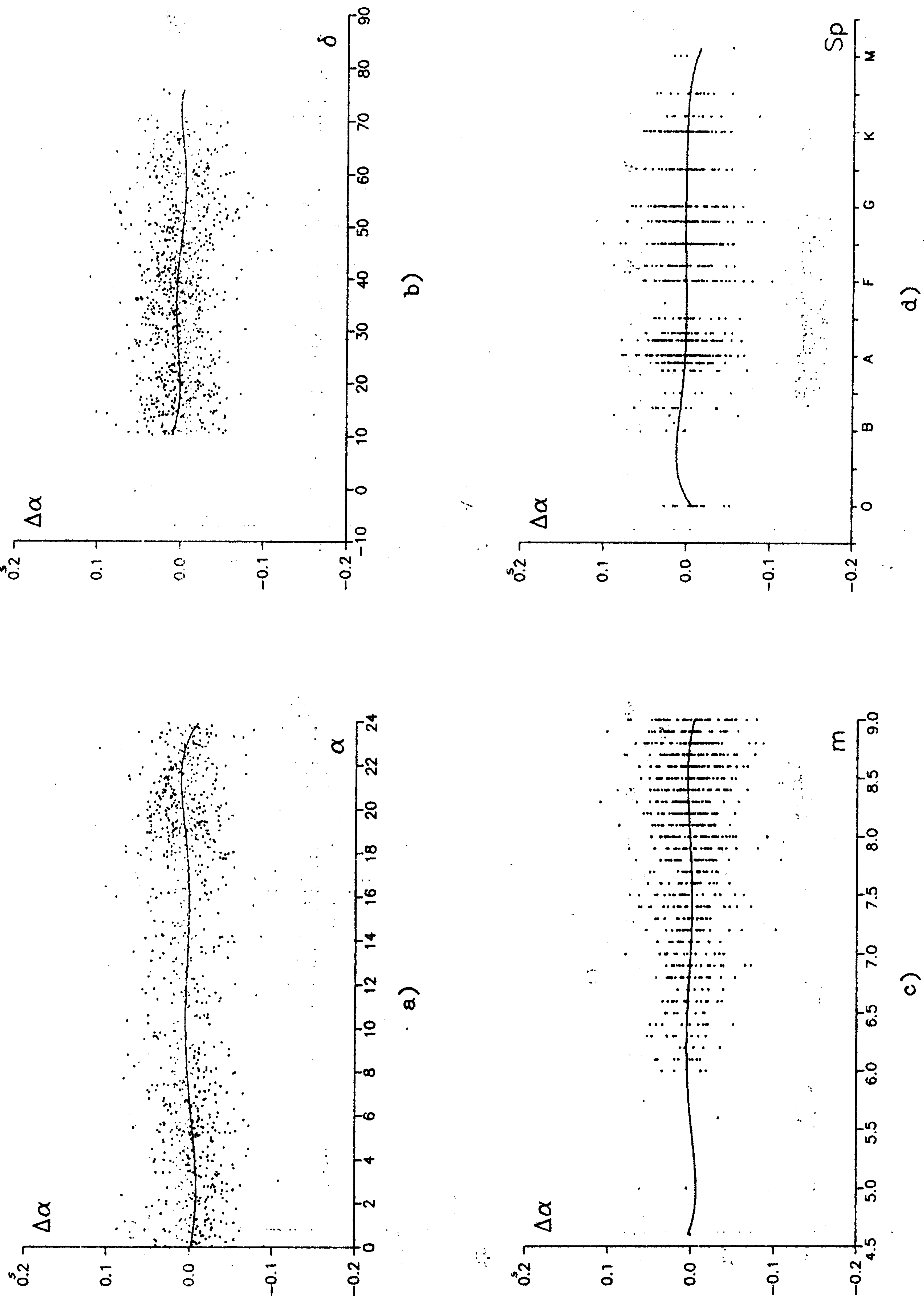


Fig. 1. Systematic differences of the Belgrade catalogue : a) $\Delta\alpha_\alpha$, b) $\Delta\alpha_\delta$, c) $\Delta\alpha_m$ and d) $\Delta\alpha_{Sp}$.

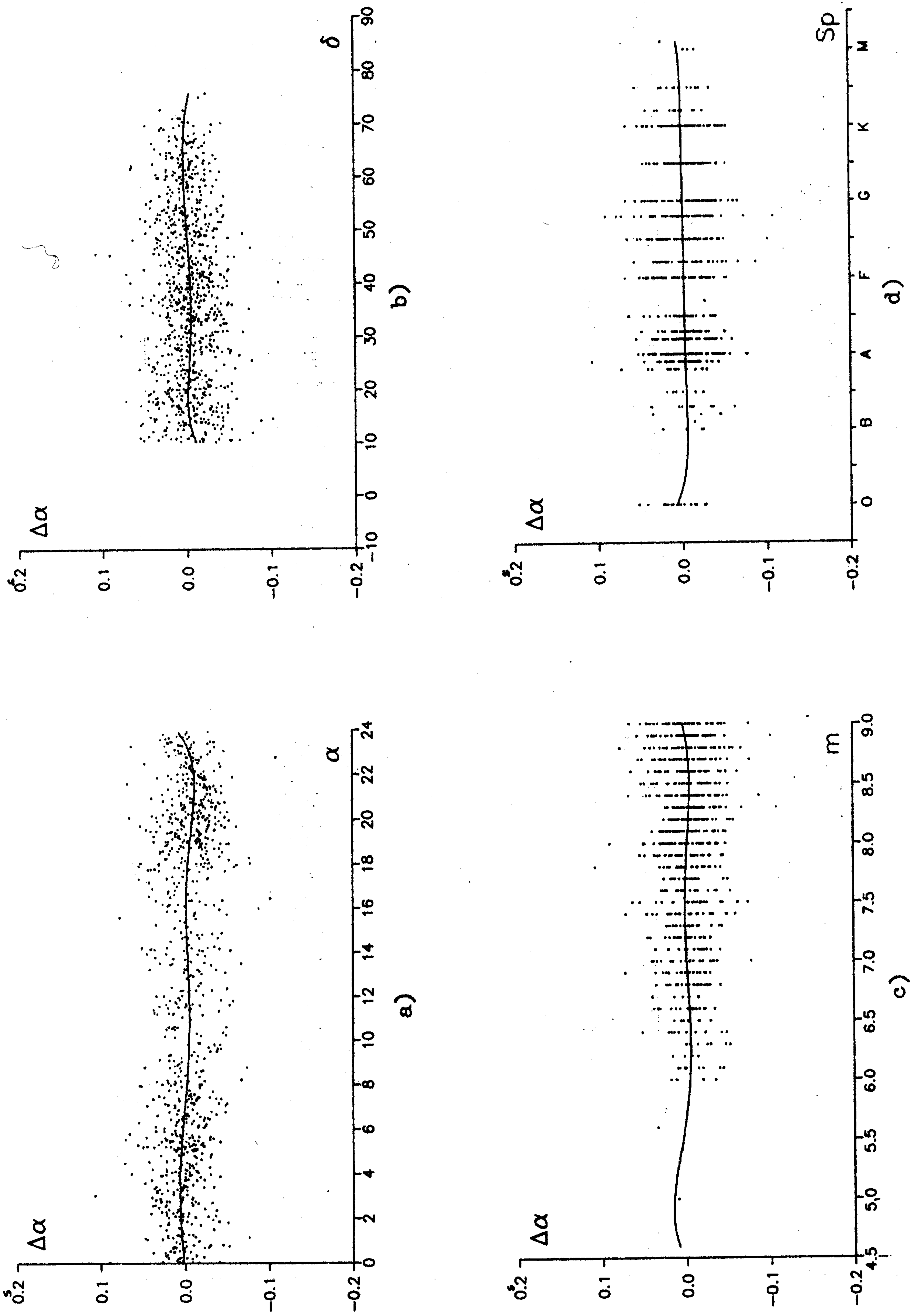


Fig. 2. Systematic differences of the Kiev catalogue : a) $\Delta\alpha_\alpha$, b) $\Delta\alpha_\delta$, c) $\Delta\alpha_m$ and d) $\Delta\alpha_{Sp}$.

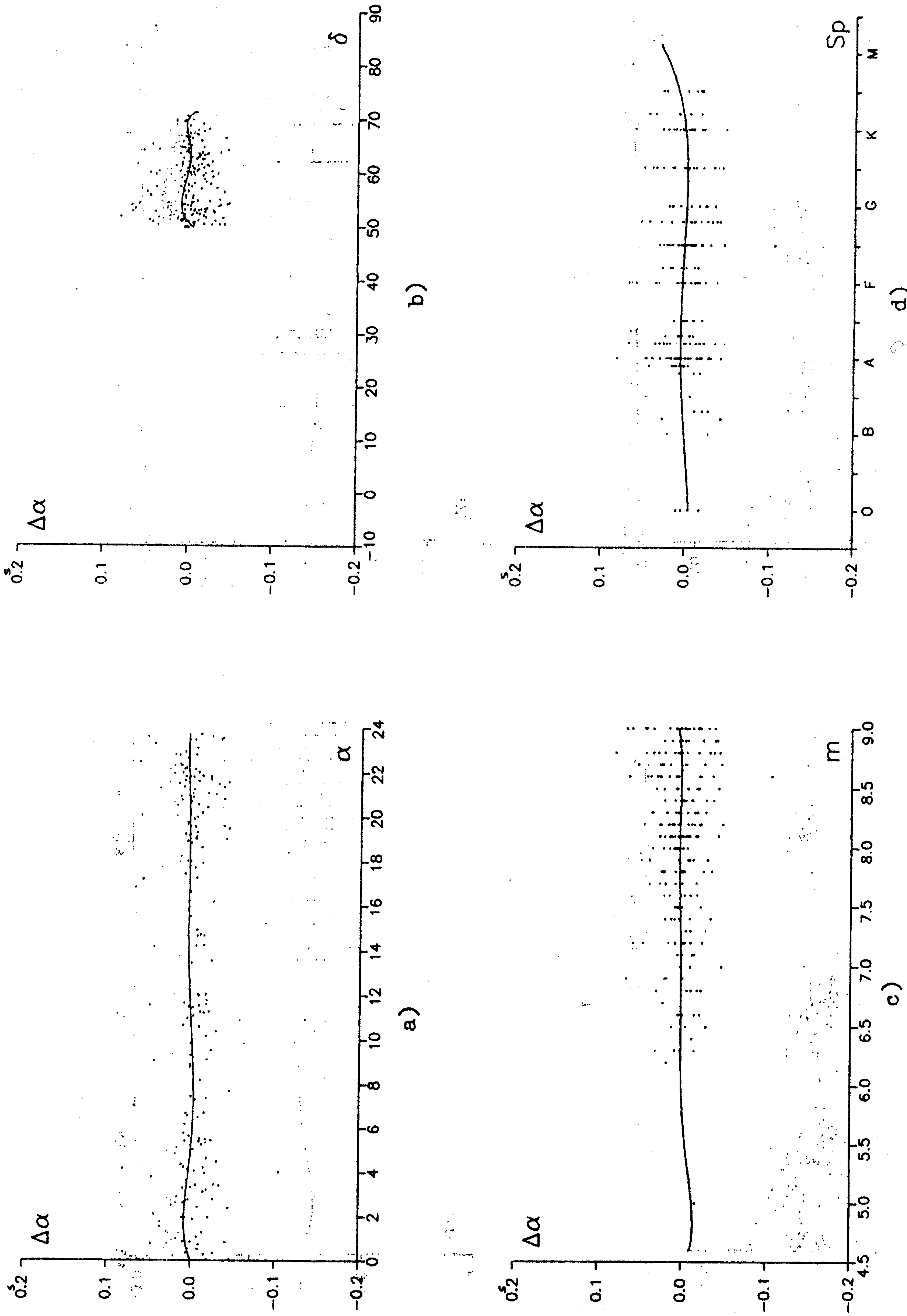


Fig. 3. Systematic differences of the Kharkov catalogue : a) $\Delta\alpha_\alpha$, b) $\Delta\alpha_\delta$, c) $\Delta\alpha_m$ and d) $\Delta\alpha_{sp}$.

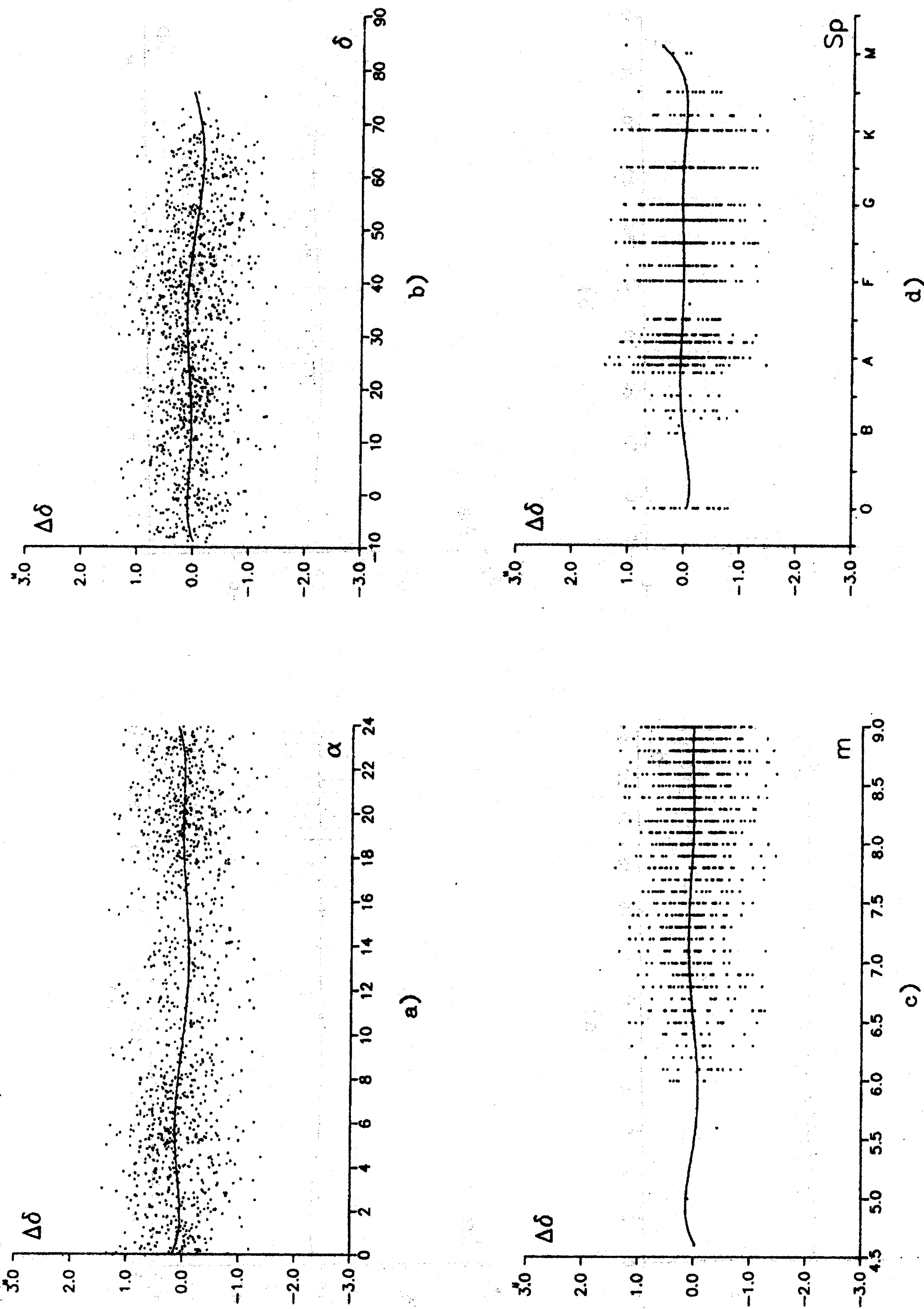


Fig. 4. Systematic differences of the Belgrade catalogue : a) $\Delta\delta_\alpha$, b) $\Delta\delta_\delta$, c) $\Delta\delta_m$ and d) $\Delta\delta_{Sp}$.

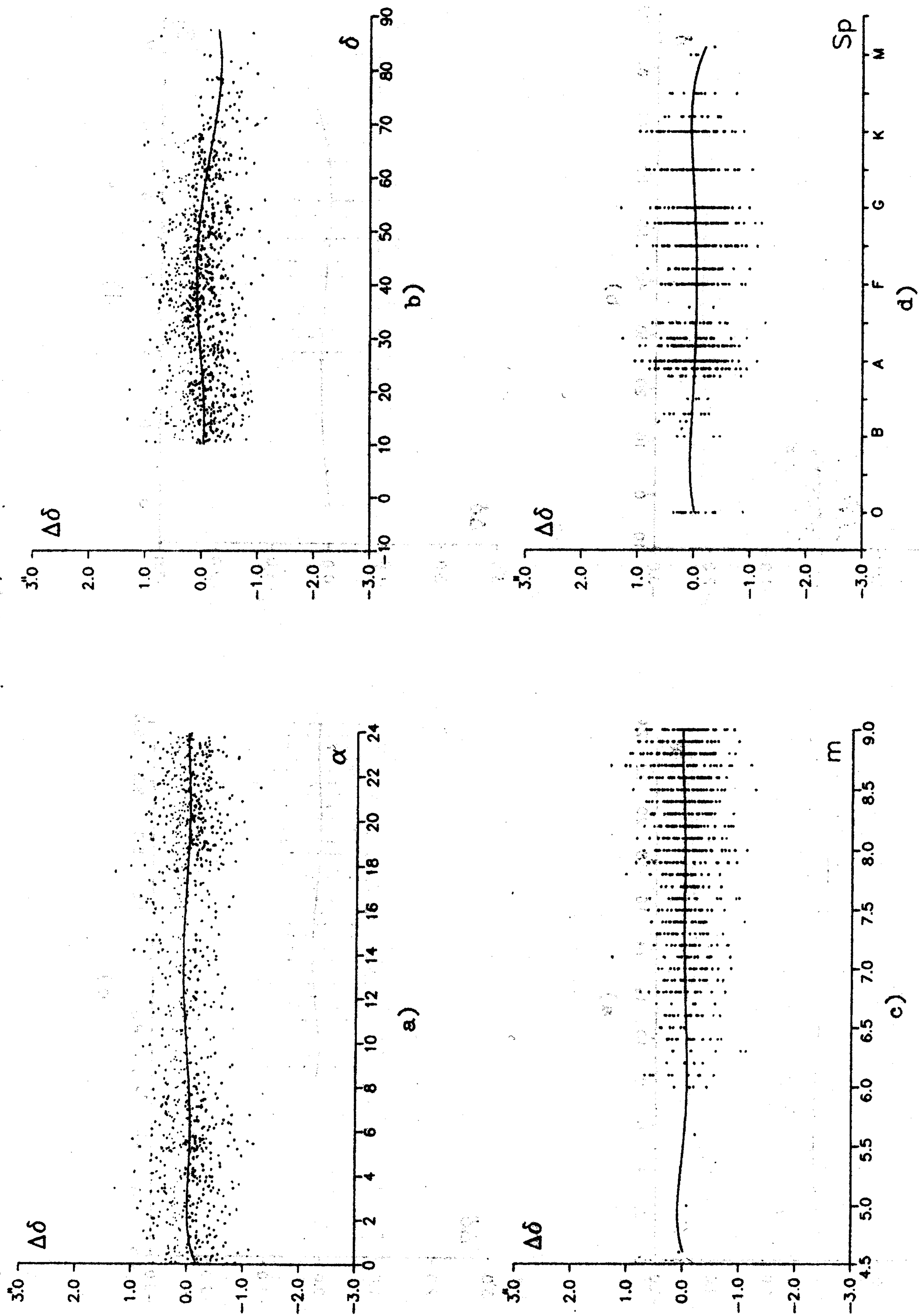


Fig.5. Systematic differences of the Kiev catalogue : a) $\Delta\delta_\alpha$, b) $\Delta\delta_\delta$, c) $\Delta\delta_m$ and d) $\Delta\delta_{Sp}$.

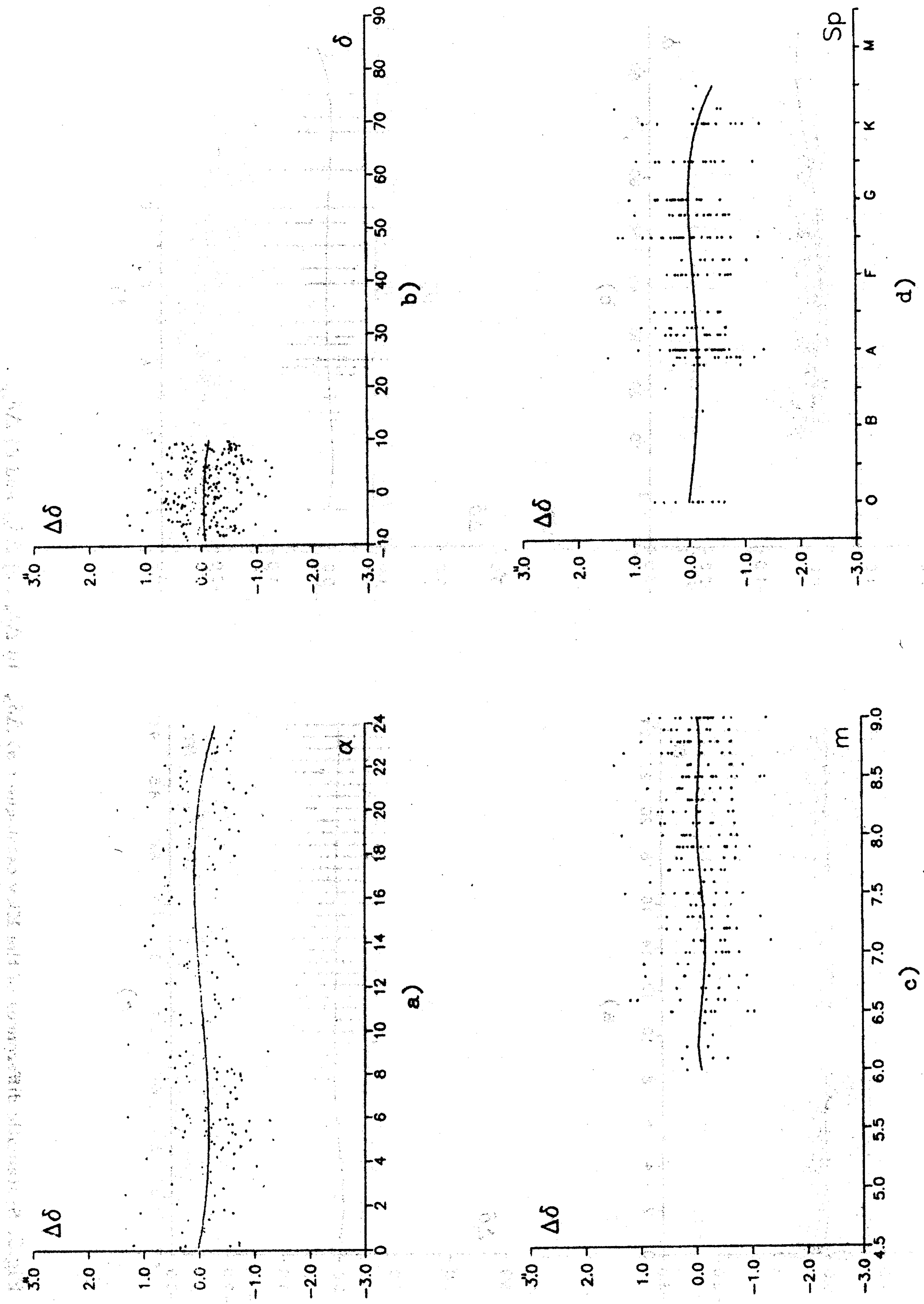


Fig. 6. Systematic differences of the Odessa catalogue : a) $\Delta\delta_\alpha$, b) $\Delta\delta_\delta$, c) $\Delta\delta_m$ and d) $\Delta\delta_{Sp}$.

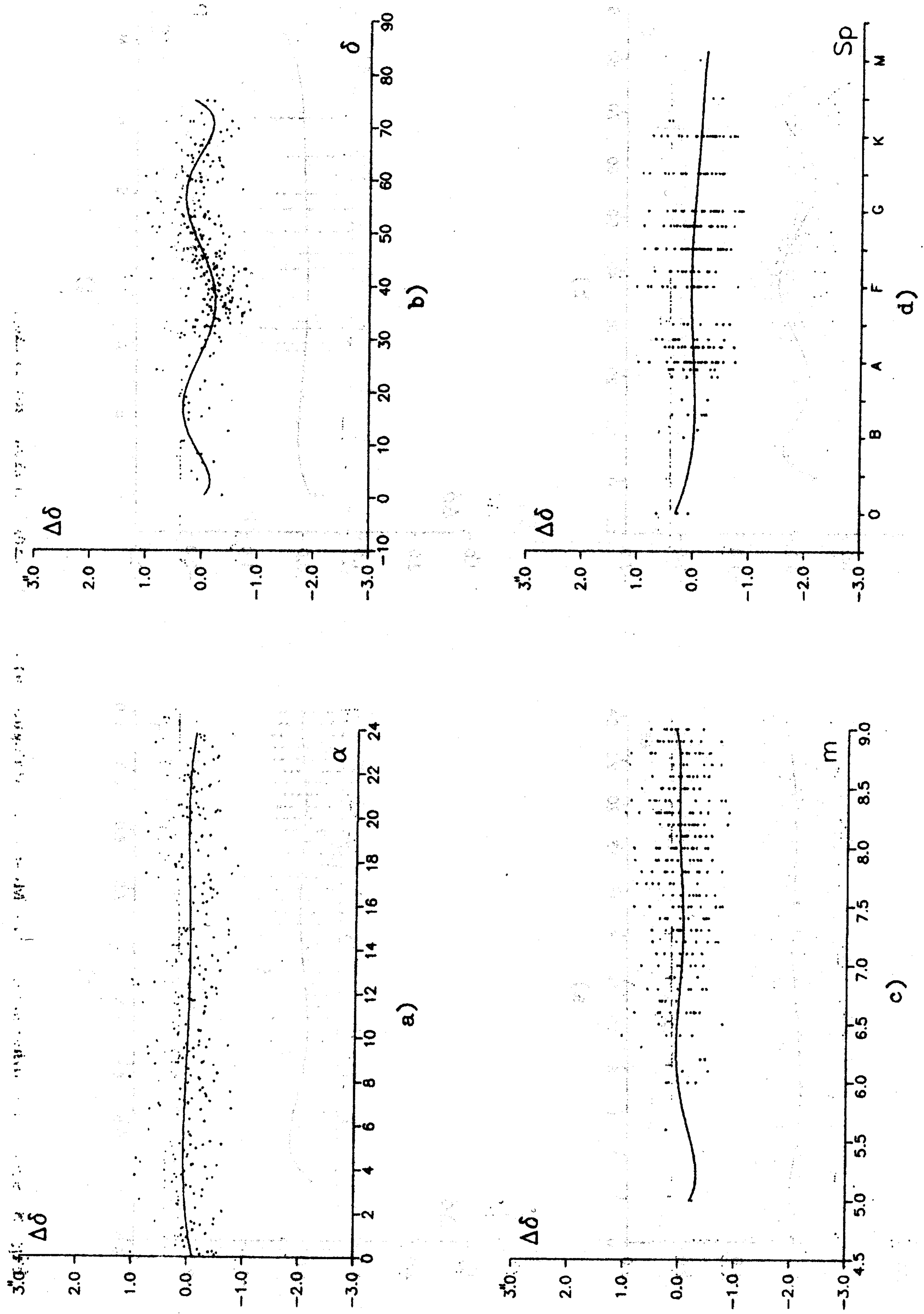


Fig. 7. Systematic differences of the Moscow 1 catalogue : a) $\Delta\delta_\alpha$, b) $\Delta\delta_\delta$; c) $\Delta\delta_m$ and d) $\Delta\delta_{Sp}$.

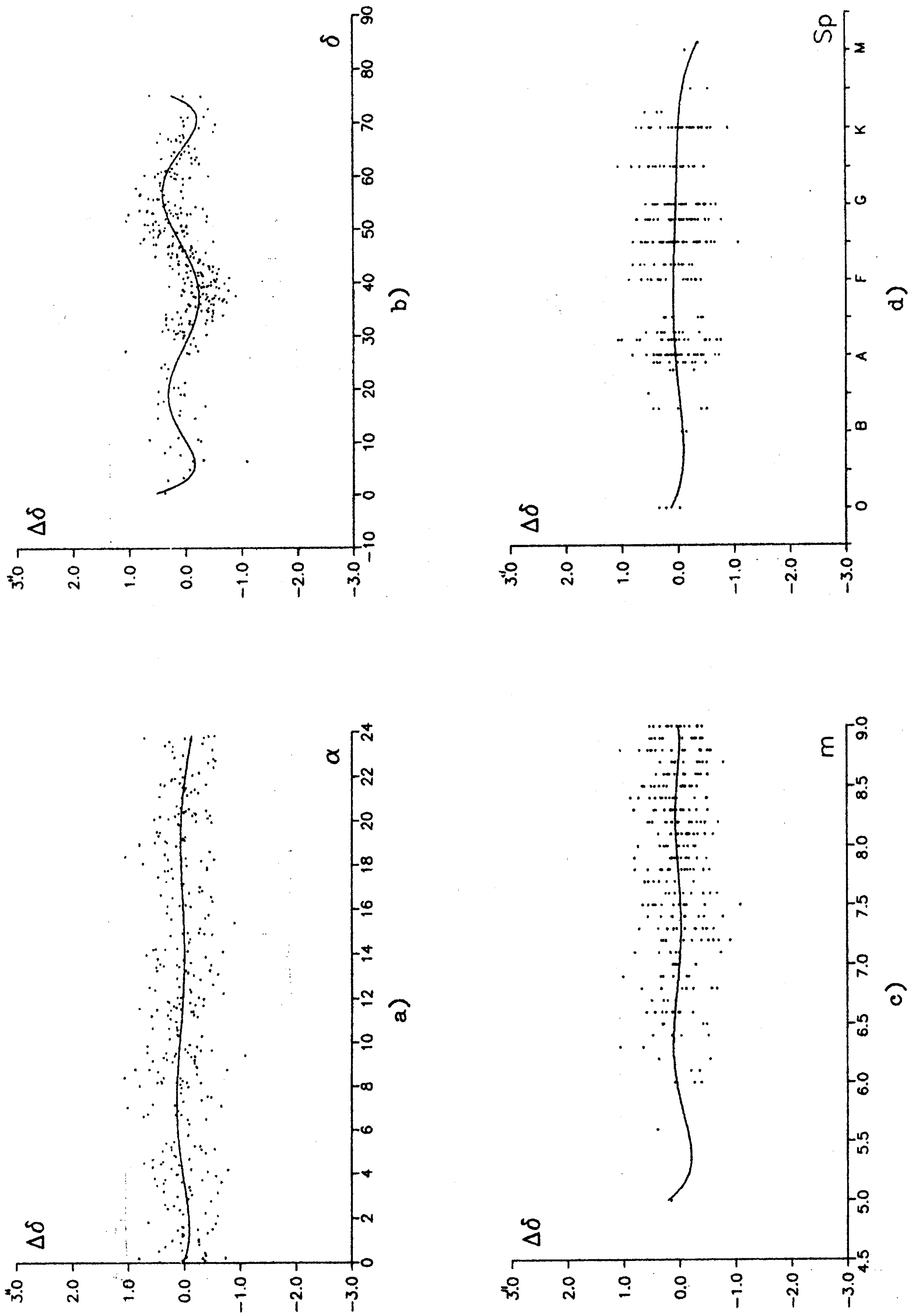


Fig. 8. Systematic differences of the Moscow 2 catalogue : a) $\Delta\delta_\alpha$, b) $\Delta\delta_\delta$, c) $\Delta\delta_m$ and d) $\Delta\delta_{Sp}$.

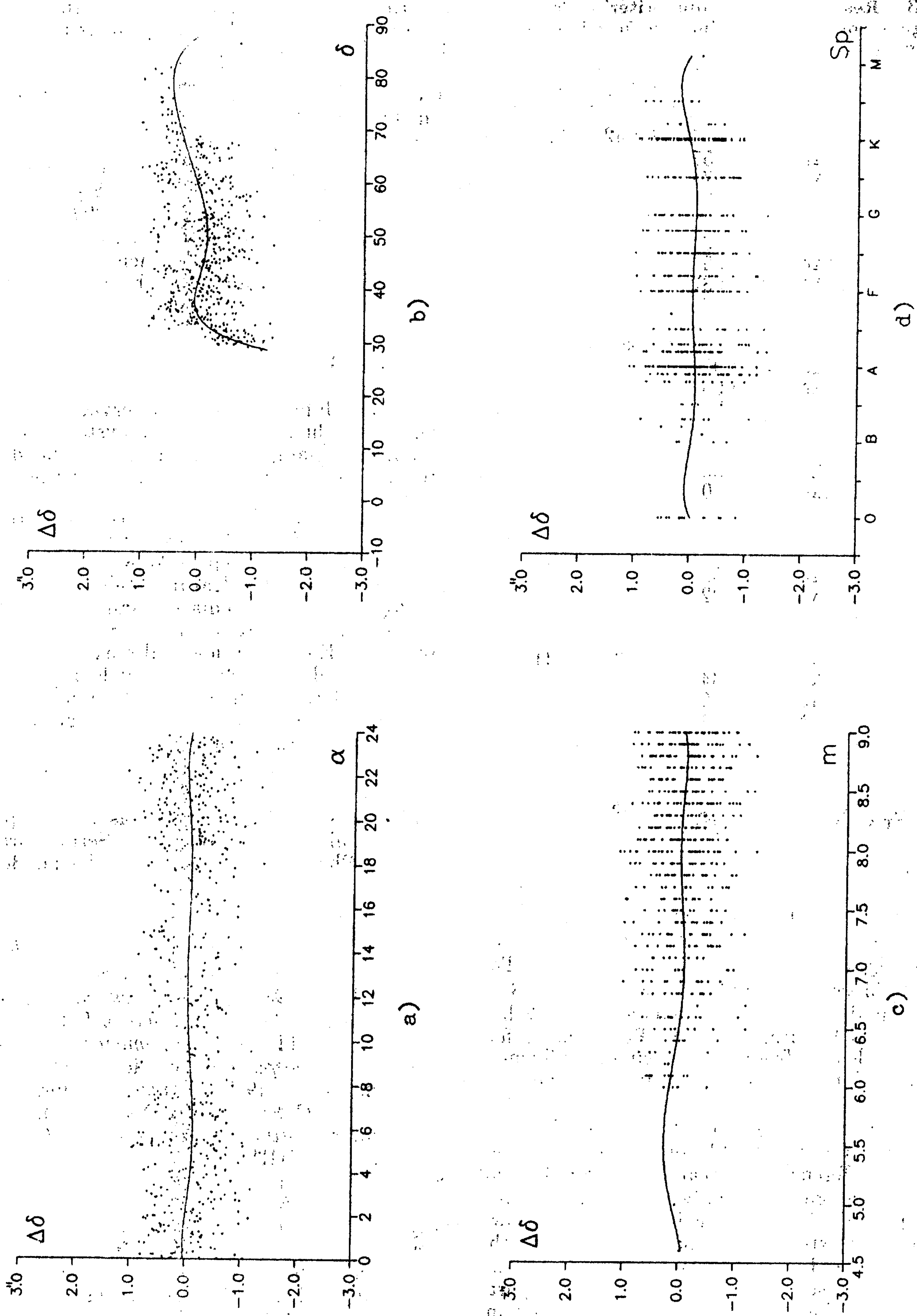


Fig. 9. Systematic differences of the Kazan catalogue : a) $\Delta\delta_\alpha$, b) $\Delta\delta_\delta$, c) $\Delta\delta_m$ and d) $\Delta\delta_{sp}$.

Table 3. Results of the Abbe criterion for catalogues containing declination for all types of dependance.

catalogue	type	$\gamma(n)$	$\gamma'(n)$	n
Belgrade	$\Delta\delta_\alpha$	0.964	0.952	1173
	$\Delta\delta_\delta$	0.957		
	$\Delta\delta_m$	0.974		
	$\Delta\delta_{sp}$	0.993		
Kiev	$\Delta\delta_\alpha$	0.991	0.947	974
	$\Delta\delta_\delta$	0.953		
	$\Delta\delta_m$	0.982		
	$\Delta\delta_{sp}$	1.027		
Odessa	$\Delta\delta_\alpha$	1.010	0.895	243
	$\Delta\delta_\delta$	0.997		
	$\Delta\delta_m$	0.968		
	$\Delta\delta_{sp}$	0.901		
Moscow 1	$\Delta\delta_\alpha$	1.011	0.907	309
	$\Delta\delta_\delta$	0.632		
	$\Delta\delta_m$	1.009		
	$\Delta\delta_{sp}$	1.006		
Moscow 2	$\Delta\delta_\alpha$	1.007	0.908	316
	$\Delta\delta_\delta$	0.586		
	$\Delta\delta_m$	0.923		
	$\Delta\delta_{sp}$	1.015		
Kazan	$\Delta\delta_\alpha$	0.998	0.935	641
	$\Delta\delta_\delta$	0.646		
	$\Delta\delta_m$	0.968		
	$\Delta\delta_{sp}$	0.940		

3. ELIMINATION OF SYSTEMATIC INFLUENCES OF $\Delta\delta_\delta$ TYPE

Aimed at excluding $\Delta\delta_\delta$ systematic influences in two Moscow catalogues a new mean declination system was formed (SS δ_4) from the other four catalogues (Belgrade, Kiev, Odessa and Kazan). The differences (Moscow 1 - SS δ_4) and (Moscow 2 - SS δ_4) were computed, and smoothing made by the Whittaker-Robinson-Vondrak method. Particular differences were released from the systematic influences $\Delta\delta_\delta$ by deduction of the corresponding smoothed values.

The new mean system computation from all the six catalogues (SS δ_6) and examination of the dependance of differences $\Delta\delta_i$ (catalogue - SS δ_6) of all types and catalogues by applying the Abbe criterion is repeated. The obtained values have shown that there still exists a systematic influence of the $\Delta\delta_\delta$ type in the Kazan catalogue. This fact implies that the assumption made in previous paragraph is wrong, i.e. the existence of systematic influence $\Delta\delta_\delta$ in the Kazan catalogue is not caused by influences of the same kind of the Moscow catalogues, but there are systematic declination changes

deforming the system of this catalogue. The elimination was made in the same way as in the Moscow 1 and the Moscow 2 catalogues.

The use of the Abbe criterion has shown that deviations of all catalogues from the new mean system (released from $\Delta\delta_\delta$ Moscow 1, Moscow 2 and Kazan) are of random nature.

From this observational catalogues the preliminary compiled catalogue of the DS-programme star positions was made (Cvetković, 1992), since following these tests we could proceed with computation of weights implied by the accidental character of $\Delta\alpha$ and $\Delta\delta$ differences, and with the computation of the derived positions.

4. CONCLUSION

The differences of the observational catalogues from the right ascension mean system do not show systematic changes, indicating that the deviations are random, i.e. that their right ascension systems are similar.

From the differences of the observational catalogues from the declination mean system systematic changes of the type $\Delta\delta_\delta$ were noticed in both the Moscow and the Kazan catalogues. In Moscow catalogues these systematic changes are caused by the instrument system errors. Systematic changes $\Delta\delta_\delta$ in the Kazan catalogue also exist and they have not been explained. Remarks made by the catalogue author and that will be payed attention to in the future work (on eventual errors in limb division corrections, refraction, photocharting the circle) could be the cause of such systematic changes.

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ПОСМАТРАЧКИ КАТАЛОЗИ ПОЛОЖАЈА ДВОЈНИХ ЗВЕЗДА (1980- 1987)
И ЊИХОВЕ КАРАКТЕРИСТИКЕ

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Оригинални научни рад

У овом раду се дају систематске разлике $\Delta\alpha$ и $\Delta\delta$ посматрачких каталога звезда DS програма урађених у периоду 1980-1987. Ове разлике су испитане на основи поређења са прелиминарно изведеним средњим системом. Користећи методу

Whittaker-Robinson-Vondrak-а за изравнање посматрачких података извршена је елиминација откривених систематских утицаја типа $\Delta\delta_s$ код три каталога.