PARIS FULL PUPIL ASTROLABE AND DANJON's PRISM ASTROLABE .
A STATISTICAL COMPARISON IN TERMS OF TIME-MAGNITUDE-COLOUR EQUATION.

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ABSTRACT. Through multivariate statistical methods, we are trying to detect and separate some "outstanding errors" in visual astrometric data, especially in terms of time, magnitude, colour effects. The methods are illustrated by their application to the Paris Astrolabe data.

1. INTRODUCTION

Up to now, Paris star observations have been used regularly for latitude and time work. For the purpose of future revision of this long term astrometric series for proper motion work and double star orbit determinations, a careful analysis of the data appears to be necessary, in particular, in terms of isolating of some "outstanding errors" related to the conditions in which the observations are performed.

2. THE DATA 1956-1982 : CHOICE OF TWO TEST-PERIODS

The Paris observations are divided into groups g=1,..12 , with $n(g,t) \leq 30$ stars observed at the mean date t, according to their sidereal time (TS) of passage. The related equations of condition are solved - at the mean date t - following a method described elsewhere (Débarbat and Guinot 1970) by an "Ordinary Least Squares" fit (OLS regression) with the usual variables , i.e., the cosine and the sine of the north azimuth Z of the star observed, and a dependent variable y which is the difference between an observed and a computed value and which contains several standard corrections (in particular, a refraction correction) which we write as DHC (or DH) depending on whether the "internal correction" (CI) of the star is (or is not) included.

The data (1956-1982) analysed here were computed with the IUA system 1964-1984 of constants. They are, nevertheless, not homogeneous because we have

(1) two instrumental periods, namely 1956-1970, the Danjon prism astrolabe (APD) with a refractive optical system, and 1970-1982,

S. Débarbat et al. (eds.), Mapping the Sky, 397–401.

https://doi.org/10.1017/S0074180900139889 Published online by Cambridge University Press

the full pupil astrolabe (APP) with a reflective - and therefore more stable - optical system , and

(2) the observer team changed.

Furthermore one finds a "non constant observer effect" on the error variances ("weights", also called "quality") of the reduction as shown by a "new observer apprenticeship curve" with high negative slope at the beginning (Bougeard 1987a).

The two test periods chosen, i.e. 1977-79 (APP) and 1965-67 (APD) proved, through factor analyses of correspondences, to be homogeneous enough in terms of group and observer effects (except for one or two observers near the small weights) on the error variance of the usual group reductions (regressions) (Bougeard 1987c). A tendency of the groups observed in summer (Nos. 11, 12, 1) to have higher variances -smaller weights- has been detected.

3. DETECTING SIGNIFICANT MISSING VARIABLES IN THE USUAL MODEL

Since missing variables in a regression model are sources of bias in estimations and correlated errors in an OLS fit (Theil 1957, Firneis and Firneis 1975, Johnston 1984, Mazodier 1981), and since some magnitude , spectral-type or time ("Bonneau effect", also called "rank error") effects were observed in the OLS astrolabe residuals, we try in this section to identify variables which are significant but missing in the usual reduction model.

3.1 Method

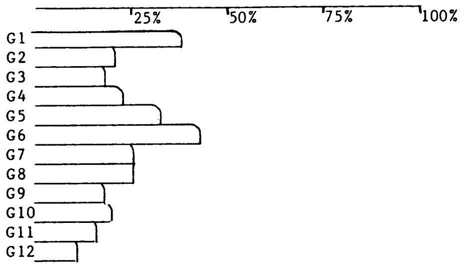
For this purpose, we do not analyse residuals separately against the rank of the star, magnitude or spectral type classes, but we rather test a linear model with explanatory variables (in a group g) which are sinZ cos Z (as usual), and the sidereal time of passage (TSO=TS - 2g + 2, TSO (-0,8h ; 0,8h)), the visual magnitude (MV) and the B-V colour in dex (BV).

The last variables were suggested by some preliminary factor analysis (Bougeard 1987a, 1988) and can originate from the refraction, either from some instrumental effect or the transmission through the observer's eye.

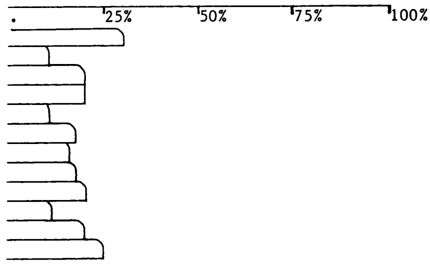
We then use a variable selection technique such as stepwise regressions at a 20% F (Fisher-Snedecor) level of significance - the use of this test assumes a Gaussian error distribution function - to detect the variables which enter and remain in the regression at the given level.

3.2 Time-Magnitude equation

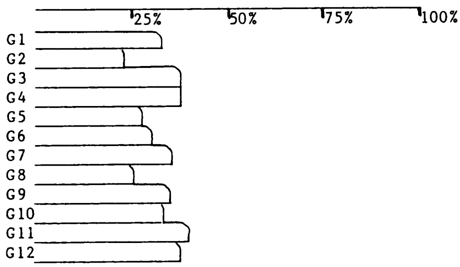
Firstly, we applied this method to time-magnitude effects (provision for the variables TSO and MV in the model and detection of the reductions from which they are significantly missing) for DH-regressions for the two test periods. The results were published by Bougeard (1987a , Tables 5.a,5.b,6.a,6.b) and are summarized in the diagrams below where the number of regressions (reductions) of each given group G1-G12 in which MV or TSO are significant is expressed in percent (for example,in group 1, period 1965-67, MV is significant in 33 group-reductions among 88 : we have drawn 33/88=37,5%).



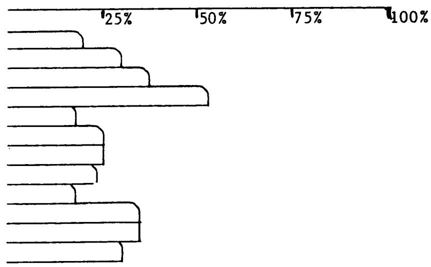
MV entry (in percent), period 1965-67



MV entry (in percent), period 1977-79



TSO entry (in percent) period 1965-67



TSO entry (in percent) period 1977-79

We note a surprising time-effect for the period 1977-79 (for an a priori more stable instrument), a large magnitude effect in group 1 (which may cause problems for the radio-star 111 (Algol/ Persei) observed in groups 1 and 4 as a catalogue star), highly different effects in the groups (problems with the usual chain-method for the evaluation of group corrections in latitude and time) and furthermore, we detected a dependence of the time-error (TSO) on the observers during the test period 1977-79 (Bougeard 1987a).

3.3 Time-magnitude-colour equation

In this section, we have analysed the "time-magnitude-colour" equation in groups 7, 8, 9, 10; group 7 has been chosen since it often appears to be a reference (zero group correction) in Time estimations evaluated by the so called "chain-method". Stepwise regressions have been performed on the explanatory variables:

sin Z, cos Z, BV , TSO , MV

for all the DH and DHC reductions of the test periods 1977-79 (full pupil astrolabe / 17258 star observations), and 1965-67 (danjon prism astrolabe / 21465 star observations). Furthermore, since the method (F test for entry of a variable in the model and F-test for the deletion of any variable which becomes superfluous) assumes gaussian errors,the following atypical stars with very influential and ill-behaved OLS residuals (see Bougeard 1987c) have been deleted: group 7: the star with rank 26 (FK4 supp 2889), group 9 : star FK4 supp 3185, and in group 10, stars FK4 supp 3594, 3733 (with ranks 13 and 28 respectively).

The following results have been observed. Quite different effects in the groups of the same test period, a high B-V colour effect in group 7 (50% of the significant entries for each period) and when the internal correction of the stars is included in the dependent variable, it magnifies in some groups (for example group 10) the time effect. In group 10, these corrections were calculated with two atypical stars with high residuals of opposite signs.

The inclusion of the internal correction also magnifies the B-V colour effect in the APP-observations of group 9 and reduces this effect in group 7. This comes from the fact that these internal corrections (calculated from Danjon's prism astrolabe observations in 1964) appear to be correlated with the B-V colour index of the stars in some Paris observation groups (by introducing an a priori internal correction, we introduce statistically a supplementary variable in the model the coefficient of which is forced to be equal to 1).

Finally, the separation of time, magnitude and B-V colour effects, has been obtained through a factor analysis of multiple correspondences by which it became apparent that on the first axis there is a separation of "entry" of these effects in the regression model and "nonentry" (group 8 near "non-entry"); on the second axis, a separation of the "time effect" from the "magnitude-colour" effects (group 7 and observer Nr 49 projected near these last ones), and on the third axis, a separa tion of the magnitude effect from the B-V colour effect for the test period 1977-79 .

4. CONCLUSION

Through different multivariate statistical techniques we have isolated some outstanding disturbing effects in the Paris Astrolabe data. These effects appear as nonhomogeneous throughout the different groups. Some of them depend on the observers and on the instrumental optical system Consequently, some care is needed in pooling the data for catalogue work as far as time, magnitude, colour effects are concerned.

Details are to be found in the References.

5. ACKNOWLEDGEMENTS

The author gratefully acknowledges financial support from the laboratories BIH and DANOF (Paris Observatory), and CNRS (UA 1125). The computations have been performed with S.A.S. at CIRCE (Orsay, France). She expresses her sincere appreciation to Dr Eichhorn H. for fruitful comments which greatly improved the composition of the Paper.

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https://doi.org/10.1017/S0074180900139889 Published online by Cambridge University Press