Rigorous Block-Adjustment of the CPC2 Cape Zone

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1. Introduction

A preliminary classical plate adjustment (CPA) of the Cape zone ($-40^\circ \geq \delta \geq -52^\circ$) of the Second Cape Photographic Catalogue (CPC2) has already been published (Nicholson et al 1984). A status report of the whole CPC2 project which provides a fourfold overlap of the entire southern hemisphere on 5820 plates with two exposures each, has been given elsewhere at this symposium (de Vegt et al 1987).

In this paper we will compare a rigorous block-adjustment (BA) solution of the Cape zone with results from classical single plate reductions (CPA), as well as with the reference star positions involved. Local systematic errors in the FK4 reference frame have been found by using the methods of photographic astrometry. Details can be found elsewhere (Zacharias 1987).

2. Data and CPA

All 1008 plates of CPC2 Cape zone have been measured on the GALAXY machine at the Herstmonceux RGO. Comparison of both exposures and preliminary reductions indicate a high precision of 110 milliarc seconds (MAS) for the standard error of a measured rectangular star position on a single plate in each coordinate. Various plate models have been tested in CPA reductions using apparent places, after the data had been corrected. Only about 97% of the measured images of 51012 stars have been used for a BA to ensure an exact fourfold overlap and exclude very discrepant images.

As the final Southern Reference Star catalogue (SRS) is not jet available, a preliminary version on the FK4 system was kindly provided by the USNO (Smith 1985), with an average central epoch around 1970. Its total precision is estimated to 150 MAS in each coordinate for the epoch of the Cape zone (1962) including the systematic errors of the FK4 system (Lederle 1978).

S. Débarbat et al. (eds.), Mapping the Sky, 201–205.

3. BA Principles

The BA method is outlined in detail elsewhere (Eichhorn 1960, Googe et al 1970, de Vegt & Ebner 1972). All plate constants of all plates of a block and all star positions are determined in the course of a single least-squares adjustment. The resulting normal equations can be reduced to a subsystem which contains the plate constants only. For the Cape zone, a system with 16000 unknowns thus results where the following 8-parameter plate model was adopted (de Vegt & Ebner 1974), with measured coordinates x,y and tangential coordinates ξ, η:

$$x = P1\,\xi + P2\,\eta + P3 + P5\,\xi + P6\,\eta + P7\,\xi^2 + P8\,\xi\eta$$

$$y = -P2\,\xi + P1\,\eta + P4 + P6\,\xi - P5\,\eta + P7\,\xi\eta + P8\,\eta^2$$

P1 to P4 describe an orthogonal transformation, P5,P6 are nonorthogonal linear constants and P7,P8 are plate tilt terms, often refered to as p,q terms. Using the HBAPP (Hamburg Block Adjustment Program Package) constraints on plate constants with appropriate weights can be introduced as well according to information obtained from CPA analysis or what we call "supplementary observations".

4. Simulations

A BA simulation was performed, using the same plates and stars as in the Cape zone and generating normally distributed errors of appropriate variances for x,y measures as well as for reference star positions. Local (average of 25 reference stars) systematic differences (BA solution minus true position) did not exceed 60 MAS, while the standard deviation of a single star position is 55 MAS in each coordinate.

Other simulations, including systematic errors of reference stars with amplitudes of about 150 MAS show that:

- long-period errors (frequency less than four along 24h in right ascension) cannot be detected with this arrangement of data,
- short-period systematic errors over a few adjacent plates will be revealed by a BA of the Cape zone.

Using no reference stars at all in a quasi free BA (Zacharias 1987), is impossible with the Cape zone data, even when one uses an orthogonal model, because of the small width of that zone. A BA of the entire southern hemisphere will be much more promising (Ebner 1970).

5. Results

BA plate constants show much less scatter around a mean value than CPA constants as illustrated for P7 in Fig. 1. Because of the small number of not error-free reference stars on a single plate which

https://doi.org/10.1017/S0074180900139609 Published online by Cambridge University Press

produces a bad error propagation for the plate constants, the CPA positions have large systematic errors which become evident in comparison with BA positions (cf. Eichhorn & Williams 1963).

Comparing BA results with SRS star positions in Fig.2 reveals local systematic errors of up to 150 MAS. Averaging along right ascension (Fig.3) gives results which are similar to those found in TC observations for the new FK5 system (Anguita 1974). Due to the steep gradient of local systematic errors in that part of the sky, photographic astrometry was for the first time able to reveal systematic errors of a reference frame (FK4).

Our investigations show that top quality photographic results from modern astrographs combined with a rigorous BA procedure are a competive tool in establishing a future homogeneous global reference frame.

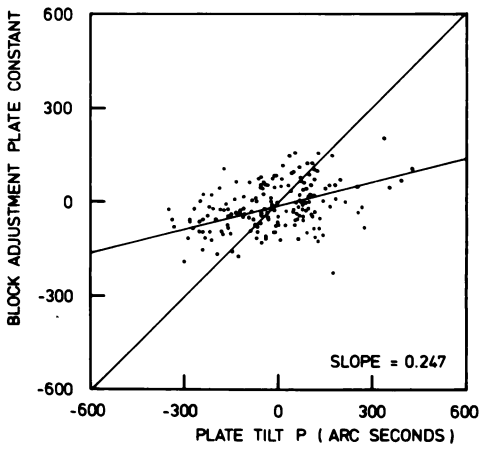

FIG.1: Block-adjustment plate constant plate tilt (p-term) against classical plate adjustment constant. Every eleventh plate was used for the plot but all 1008 plates were utilized to calculate a regression line.

6. References

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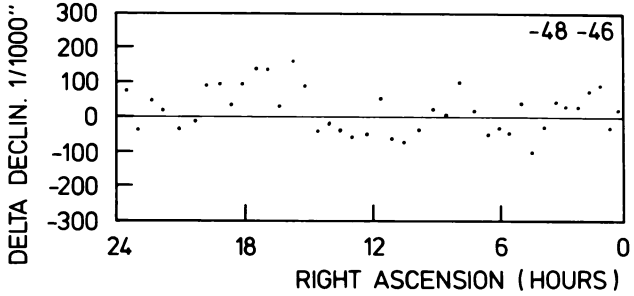


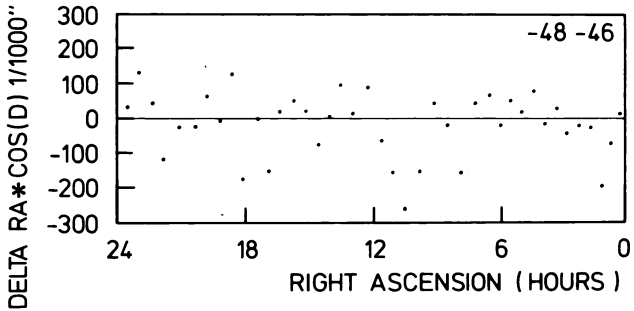
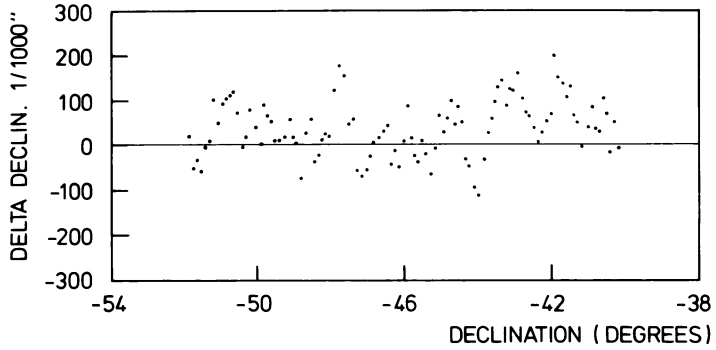


FIG. 2: Local systematic errors (BA - SRS) in right ascension times cos (D) and declination along right ascension for a zone of two degrees width in declination. Ten reference stars are averaged to a dot, which will have a random BA standard error of less than 20 MAS. The local systematic error of BA is estimated by simulations to 60 MAS at maximum.



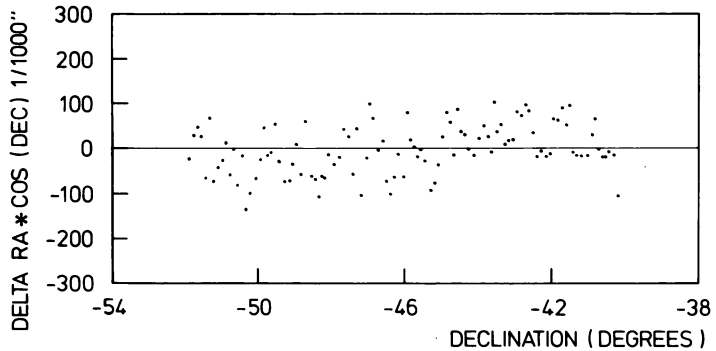


FIG. 3: Local systematic errors (BA - SRS) averaged over full range in right ascension against declination. Twenty-five reference stars are averaged to form a dot. Compare these results with TC observations of SRS stars (Smith 1985, Anguita 1974, Schwan 1987).

Discussion:

EICHHORN This is a monumental piece of work. Everyone who participated in it should be congratulated.

ZACHARIAS Thank you.

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