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Secular Variation of Carloforte Latitude

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Abstract. The long series (1899.9–1979.0) of latitude observations made at Carloforte in the framework of the International Latitude Service is analyzed to determine a secular trend. The value of the linear rate obtained from the classical astrometric results agrees fairly well with the value derived from recent SLR and GPS observations carried out at the Cagliari Observatory.

1. Introduction

Regular latitude observations were carried out at the Astronomical Station of Carloforte starting from October 1899 through December 1978 with a visual zenith-telescope under the framework of the International Latitude Service (ILS). The observations were made continuously with the exception of an interruption in the years 1944–45 during World War II. The total number of the star pairs observed and nights are 174,418 and 14,784 respectively.

Recently Satellite Laser Ranging (SLR) and Global Positioning System (GPS) observations started at the Cagliari Astronomical Observatory located at the same parallel of Carloforte, about 90 km East. The series of astronomical latitude observed at Carloforte can be examined to determine the trend over this century to be compared with the drift derived by modern space geodesy in the last years.

2. Astronomical latitude variation

The values of Carloforte latitude used here are those provided by the ILS (Yumi & Yokoyama 1980) reduced in a homogeneous system and corrected for their declination errors by the chain method, from which we first subtracted the Kimura z-term that represents the common variation of latitude of all the ILS stations. In order to filter out the Chandler and annual terms the series has been smoothed by the Vondrák method with $\epsilon = 10^{-7}$.

The values thus obtained are plotted in Figure 1. A small northward variation is shown. If the component of the secular polar motion along the Carloforte

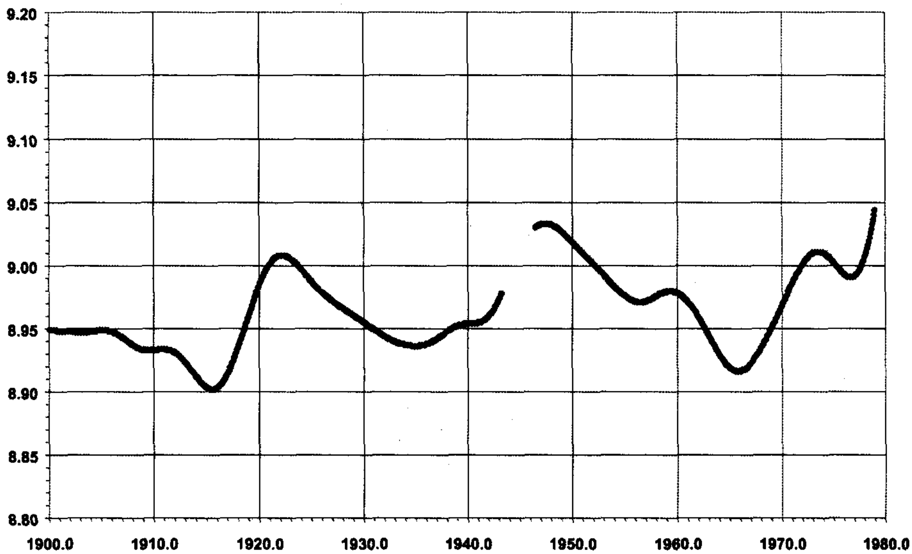

Figure 1. Carloforte observed latitude (excess from 39°08'), in arcsec.

meridian is also removed we should obtain the trend due to non-polar, probably local, effects.

Assuming for the secular polar motion the last published values x = 0.68 mas/yr and y = 3.32 mas/yr (Vondrák *et al.* 1998) its component along the Carloforte meridian is 0.19 mas/yr. After removal of this progressive term we obtain the values shown in Figure 2 and, by the method of least squares, the following linear trend in Carloforte latitude:

$$d\phi/dt = 0.40 \pm 0.04 \text{ mas/yr},$$

corresponding to 12.3 ± 1.2 mm/yr, which is in very good agreement with the value of 0.48 mas/yr provided by the Nuvel-1 NNR model for global plate tectonics derived from geophysical observations averaged over the last 3 million years (Argus & Gordon 1991), assuming Carloforte to be located on the Eurasia tectonic plate.

3. Latitude variation from space geodesy

SLR observations have been made at the Cagliari Observatory since 1988 with a mobile laser system, and a fixed system is operational since 1993. In the few last years also, GPS tracking data have been obtained. Both techniques, currently contributing to IERS and ITRF solutions, provide accurate information on the horizontal motions confirming Sardinia to be located on the stable part of the Eurasian plate.

As an example, some recent estimates by GPS measurements give 12.7 ± 0.4 mm/yr (0.41 ± 0.01 mas/yr) for the drift in latitude.

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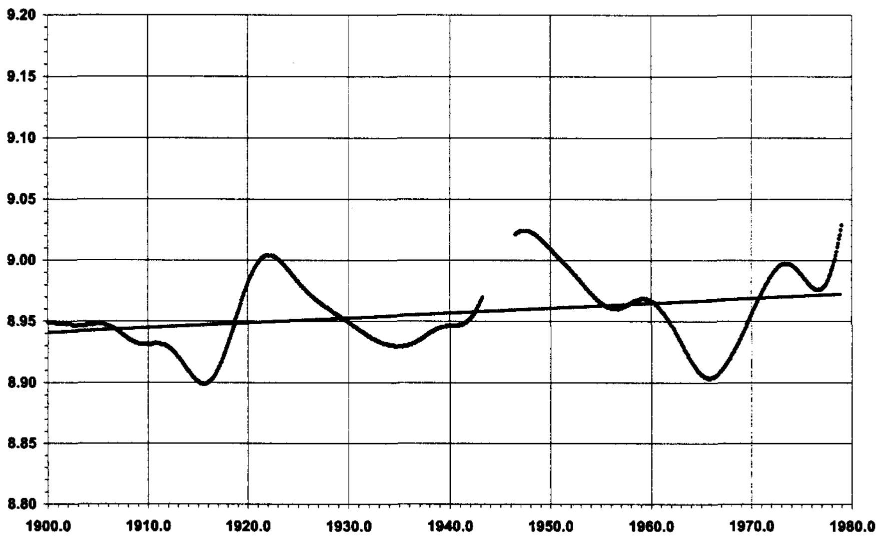

Figure 2. Carloforte latitude after removal of the secular polar motion, in arcsec.

Considering then the velocities of the Cagliari site (N. 12725) at the epoch 1997.0 given in ITRF97 (Boucher *et al.* 1999)

$$V_x = -10.8 \pm 0.8 \text{ mm/yr}; \; V_y = 19.4 \pm 0.7 \text{ mm/yr}; \; V_z = 10.5 \pm 0.7 \text{ mm/yr}$$

by means of

$$V_\phi = -(\sin\phi\cos\lambda V_x + \sin\phi\sin\lambda V_y - \cos\phi V_z)$$

where λ is the longitude, the linear variation of Cagliari latitude 0.42 ± 0.03 mas/yr is obtained in excellent agreement with the above value derived by optical astrometry.

4. Comparison with other results

In the last few years the IAU Working Group chaired by J. Vondrák has completed a new global re-reduction of past optical time and latitude observations, including those of the ILS, referred to the Hipparcos catalog and the IAU standards (Vondrák *et al.* 1998). The non-polar drift found for Carloforte is 1.30 mas/yr to be added to an *a priori* tectonic motion as 0.61 mas/yr removed from the original data, so the total drift is 1.91 mas/yr. This value is apparently far from the one we found. Analogous large differencies are found for the other ILS stations.

These differencies, however, are found to be eliminated almost completely when all the values of secular variation in latitude of the ILS stations are corrected for a common term probably due to systematic deviation of the proper motions of the observed stars.

This is also evident from Table 1 where relative differences in trend between Cagliari and both Kitab and Mizusawa latitude are reported.

Table 1. Relative latitude variations.

	Cagliari (Carloforte) - Kitab (mas/yr)	Cagliari (Carloforte) - Mizusawa (mas/yr)
Present work	0.40 ± 0.06	0.99 ± 0.06
ITRF97	0.30 ± 0.04	0.85 ± 0.13
Nuvel 1 -NNR	0.47	1.02
Vondrák *et al.* (1998)	- 0.14	0.64

5. Conclusions

Because of the long span covered by the ILS data set and its homogeneity, the drifts obtained by optical astrometric determinations appear to be consistent with the ones obtained by more accurate geodetic measurement. In general these drifts, at least for the 3 stations considered here, appear to be completely explained in terms of tectonic motions.

It is important to note the common difference between the ILS results referred to their internal catalog and the ones referred to the Hipparcos reference frame. This might be due either to a progressive change in all the zeniths or to systematic deviations of the observing program proper motions, as just noted by Vondrák *et al.* in the above quoted paper.

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