MULTIDISCIPLINARY STUDIES OF THE VARIATIONS IN THE BELGRADE MEAN LATITUDE

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Abstract. The topic concerns the importance of the studies of the variations in the Belgrade mean latitude and their connection with the seismical activity of the soil on which the instrument is mounted.

1. INTRODUCTION

The first determinations of the precise Belgrade longitude (λ) at the Belgrade Observatory were begun in 1938 (Brkić, 1968) by using a small transit instrument (Bamberg, $2r = 100mm$, $f = 1000mm$), whereas the precise latitude (φ) was determined for the first time in 1947 (Djurković, Ševarlić, Brkić, 1951) by using a visual zenith-telescope (Bamberg, $2r = 110mm$, $f = 1287mm$); from January 1949 till now the latter has been regularly determined by applying Talcott's method. The following values have been found

$$\lambda = -1^h 22^m 03.^s 212$$

and

$$\varphi = +44°48'13.''167 \pm 0.''008.$$

The results obtained concerning the Belgrade latitude (Grujić et al., 1989) indicate an effect of latitude variation due to the polar-motion influence, as well as to the nonpolar ones. The nonpolar influences have various sources : the instrument, the observers, the catalogue, the atmosphere, the geophysical changes of the soil etc.

An analysis of the z-term and the instrument's inclination β (Djokić, 1970, and Djokić, 1975) indicated correlation between them. Also, it revealed a tendency of the instrument's permanent drifting to the southwest, an effect explaining partially the real decreasing of the Belgrade latitude.

On the basis of the results of the geodynamical studies obtained up to now one can conclude that there are horizontal and vertical shiftings of the soil upon which Belgrade lies. In 1988 multidisciplinary studies of the variations in the Belgrade mean latitude including seismological, geodetic, astronomical, geological and geophysical examinations concerning the area of Belgrade and aimed at establishing mutual relationship in the obtained results (Sadžakov, Grujić, 1991) were initiated.

Therefore, our research concerning the variations in the Belgrade coordinates of requires examinations of the soil shifting. The results obtained by comparing the latitude variations at Belgrade and Warsaw (Jozefoslaw) based on astronomical observations (Teleki, 1969) fully confirm that such a study is justified.

The latitude stations of Belgrade and Warsaw are almost on the same meridian so that any polar influences in the differences of their latitudes (instantaneous) are negligible. Therefore, these differences are subjected to the influences of the local factors.

Since the Belgrade latitude determinations cover a significantly long time (from 1949 till now, without interruptions), it is possible to use the astronomical material, together with the available seismological data (covering 1964-1985), in order to attempt answering the question of whether the seismical processes cause variations in the latitude. Indications concerning the seismical activity can be found by studying the evidence on the earthquakes which took place in the given area. It is necessary to incorporate the foci of those earthquakes which caused microseismical effects on the Belgrade territory. In view of this fact in the present paper only the earthquakes above the magnitude threshold of $M = 3$ are included. This threshold value corresponds to the lower reliability limit of the seismic data obtained with the Belgrade seismograph.

2. STUDIES OF LATITUDE VARIATIONS

The astronomical observational material gathered between 1949 and 1985 was treated in the FK5 system.

We started from the basic formula :

$$\varphi - \varphi_0 = x * COS\lambda + y * SIN\lambda + z \tag{1}$$

$$\lambda - \lambda_0 = (1/15) * (x * SIN\lambda - y * COS\lambda) * tg\varphi \tag{2}$$

where : λ_0 (the west longitude) and φ_0 are the mean longitude and the mean latitude, φ is the observed latitude, x and y are the coordinates of the pole with respect to the mean one, and z is a term being a sum of all the nonpolar influences, such as the catalogue errors, refraction anomalies, instrument errors, shortcomings in the data treatment, various geophysical factors, etc. The mean latitude φ_0 for a given moment is that latitude value for a station from which all the nonpolar and polar periodical terms are excluded. The results of φ_0 examinations have confirmed its variable character. The secular variations may be due to the secular motion of the mean pole whereas the others are due to the local changes of the site position (Kulikov, 1962).

By eliminating the most important periodic polar motions from the latitude variations one obtains the value of the mean latitude (φ_0') by use of Orlov's formula

$$\varphi_0' = \frac{1}{20} \sum_{i=0}^{i=4} (\varphi_i + \varphi_{i+5} + \varphi_{i+6} + \varphi_{i+11}) \tag{3}$$

The results obtained in this way are presented in Figs 1 - 2. In Fig. 1 there is a rectilinear trend, whereas in Fig. 2 the trend is parabolic.
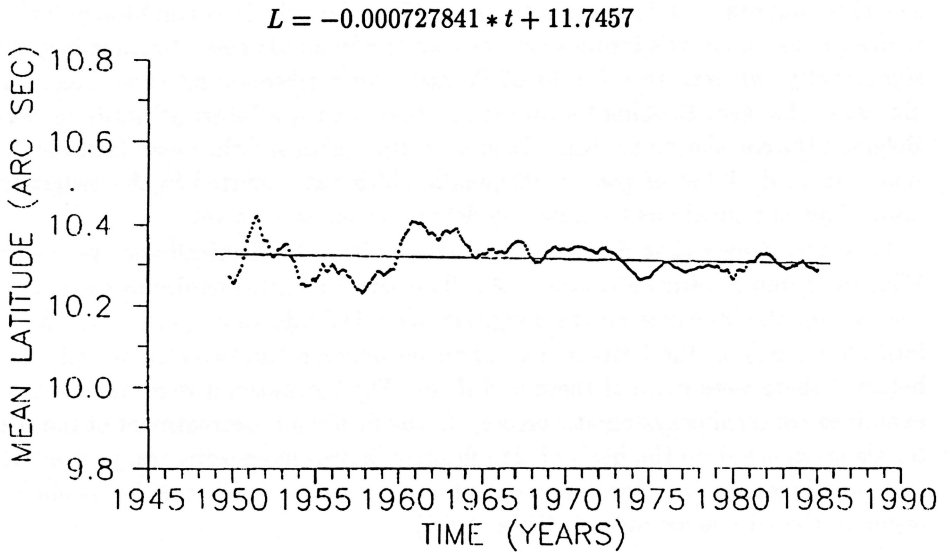
$$L = -0.000727841 * t + 11.7457$$

Fig. 1.   The curve of variations in the mean latitude with linear trend (L).

$$L' = -0.000118275 * t * *2 + 0.464686 * t - 446)93$$
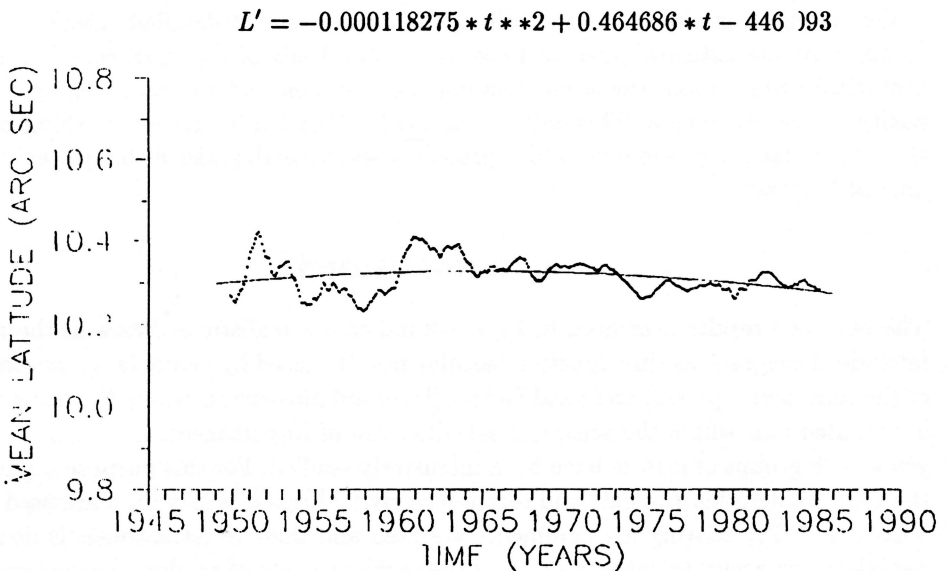

Fig. 2.   Variations of the mean latitude with their parabolic approximation (L').

Some periodic low-intensity influences, remaining after the application of Orlov's formula are discovered by use of the spectral analysis. In view of their small amount they will not be taken into account in the further work.

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3. ANALYSIS OF THE OBTAINED RESULTS

The first analysis of the Belgrade-Warsaw latitude differences after removing from the Belgrade material certain systematic errors (Damljanović, 1994) and the polar periodicities (by using Orlov's formula) shows that the Belgrade mean latitude has changed significantly, whereas in the case of Warsaw the corresponding value has remained almost unchanged. Looking for an explanation of such a "stormy" latitude curve for Belgrade the correlation between the great earthquakes and the mean-latitude changes was examined. A list of great earthquakes which have ocurred in the Belgrade area made does not enable us to draw any definite conclusion as yet.

It is well known that Belgrade is situated within a seismically active region and Warsaw within a seismically stable one. This circumstance enables us to judge about the earthquake influence on the Belgrade mean-latitude value (and generally on the latitude values) on the basis of a comparison between the two stations (it would be better if there were more of them and if the Warsaw material were more thoroughly examined concerning systematic errors). In the future a re-retreatment of the two materials is expected on the basis of significantly improved coordinates, proper motions and parallaxes for the stars observed at both stations which w ll be available as a result of the Hipparcos mission (ESA, 1989).

As a consequence a cooperation of astronomers, seismologists, geodesists, geophysicists and others concerning the present task has developed. This cooperation is realised as a scientific project after which the present article is named.

Our research is aimed at establishing the parameters of detailed seismic regionalization of the extended area of Belgrade on the basis of the data concerning the geological composition, the seismotectonic construction and the seismoenergetic capacity of the given area. This will be the base to the study and establishing of the short-term natural phenomena which precede a severe earthquake within the extended area of Belgrade.

4. CONCLUSIONS

The obtained results presented in Figs. 1-2 indicate a realistic decrease in the mean latitude of Belgrade as time function (secular trend) caused by global (e. g. movements of the continental plates) and local factors (local soil movements where the instrument is mounted and where the seismical activities are of importance). During a few last years both groups of factors have been intensively studied. For this purpose nowadays the most modern instruments and techniques giving high-accuracy data are used (like VLBI). Lokally, existing measurements are used and their re-retreatment is done by applying new accurate catalogues and other achievements of modern astronomny.

In view of what has been said above we hope that at least a partial explanation of the behaviour of the Belgrade mean latitude found here will be offered in the near future.

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