A GLOBAL GRAVITY OSCILLATION DETERMINED BY SUPERCONDUCTING GRAVIMETRY MEASUREMENTS AND ASTRONOMICAL LATITUDE OBSERVATIONS

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A global gravity long-period nontidal oscillation is determined by means of superconducting gravimeter data from the Brussels Observatory and latitude observations from zenith telescope at the Plana Observatory in Bulgaria. The used gravimetry data from Brussels consists of a few series one-hour normal values of the measurements between 1982 and 2000. The time series are filtered and the non-tidal variations of the gravity at the Brussels Observatory are derived. The non-tidal variations of the gravity at Brussels consist of instrumental drift, seasonal oscillations, polar tides and a long-period oscillation with an amplitude of about 50 nm/s^2. A similar long-period oscillation is detected in the variations of the vertical in the meridian plane at Plana in Bulgaria by means of the latitude observations from zenith telescope since 1987. The amplitude of this oscillation of the vertical at the Plana Observatory is about 0.01 arcsec.

INTRODUCTION

The investigation of the variations of Earth parameters in time and their connection with natural phenomena is very important to make a study of the natural risks and the environment changes. Necessary precondition for such investigation is the presence of many years' permanent observations. Such kinds of observations are the astronomical series of latitude and universal time observations. Recently, some long series of gravimetric measurements with superconducting gravimeters are available for investigations.

SUPERCONDUCTING GRAVIMETRY DATA AND NONTIDAL GRAVITY VARIATIONS AT THE BRUSSELS OBSERVATORY

The tidal data from superconducting gravimeter at the Brussels Observatory consist of several series of measurements since epoch 1982.4 (Fig. 1). The measurements were interrupted for a month between October 15, 1986 and November 15, 1986, and that interruption separates the data into two different series with significant increase of the nontidal trends. The nontidal variations of the gravity are determined by 29.5d averaging filter in the sliding window, which remove all tides with periods shorter than one month. The nontidal variations of the gravity at the Brussels Observatory, after removing the pole tide, consist of seasonal, long-periodical oscillations and an abrupt jump for the period 1986.0–1987.5 (Fig. 2). This abrupt jump is connected with the measurements interruption and has probably instrumental origin, therefore, in the next analysis only data after 1987.5 will be used.

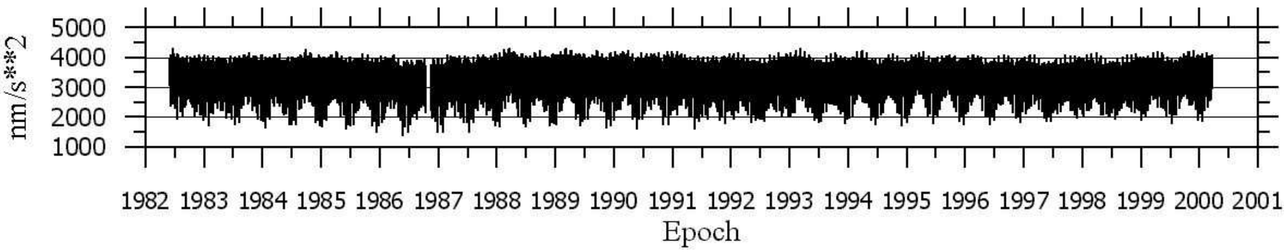

Figure 1. Tidal data from superconducting gravimeter at the Brussels Royal Observatory in one-hour normal points

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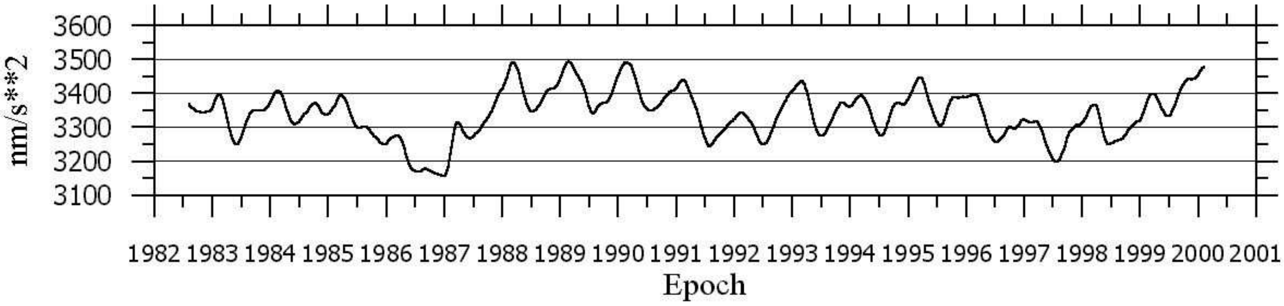

Figure 2. Nontidal variations of the gravity at the Brussels Royal Observatory, determined from the superconducting gravimetry measurements by the averaging filter

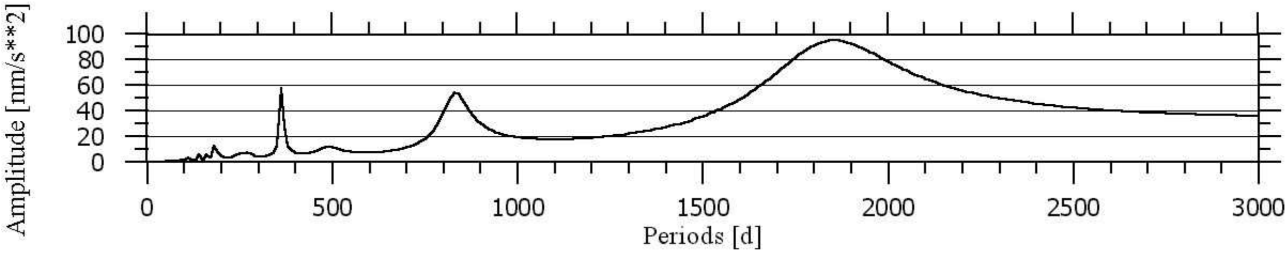

Figure 3. Spectrum of the nontidal variations of the gravity at Brussels for the period 1987.5–2000.1

The spectrum of the nontidal variations of the gravity at Brussels for the period 1987.5–2000.1, obtained by the method of maximum entropy, consists of three peaks with periods 1a, 2.3a and of about 5a (Fig. 3). The long-period nontidal variations of the gravity at Brussels are determined with running average in 500d and 2a windows (Fig. 4), and after 1986 they consist of two cycles with duration between five and six years.

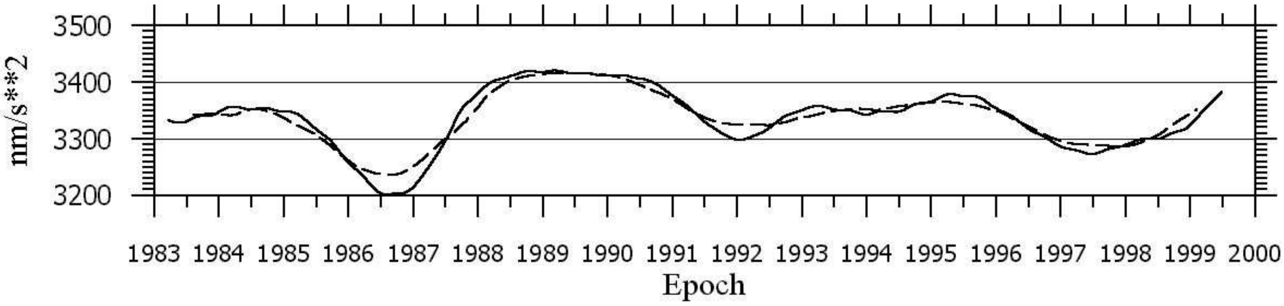

Figure 4. Long-period nontidal variations of the gravity at Brussels determined by two-year averaging (with dashed line) and by 500-day averaging (with continuous line)

ASTRONOMICAL LATITUDE DATA AND OSCILLATION OF THE VERTICAL AT THE PLANA OBSERVATORY

The used here astronomical latitude data consist of observation series from Zeiss 135/1750 zenith telescope at the Plana Geodetic Observatory since July 1987. The latitude observations are processed by several methods [1, 2] for determination of various corrections of the data and the time series of the latitude and vertical variations. The smoothed time series of the latitude changes of the Plana Observatory is shown in Fig. 5 together with the polar latitude changes, obtained from the solution C04 of the IERS. The differences between these two time series determine the oscillations of the vertical at the Plana Observatory (Fig. 6), where short-period seasonal oscillations dominate. The long-period oscillations of the vertical are determined by removing the seasonal variations with the 500-day averaging filter (Fig. 7).

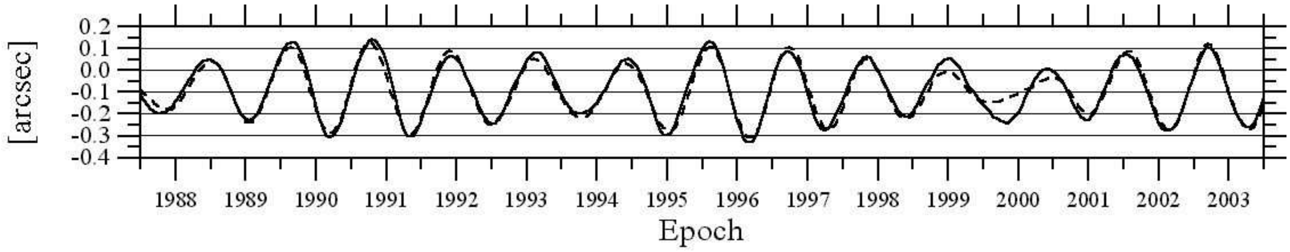

Figure 5. Time series of the latitude changes of the Plana Observatory (solid line) and polar latitude changes (dashed line), determined from the C04 IERS solution for pole coordinates

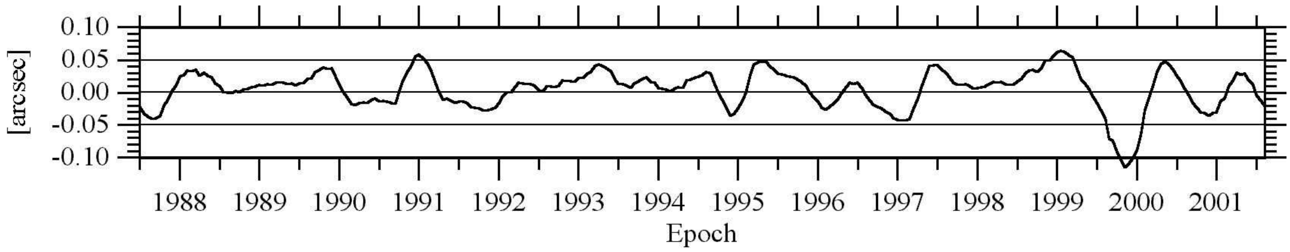

Figure 6. Nonpolar latitude changes and oscillation of the vertical at the Plana Observatory

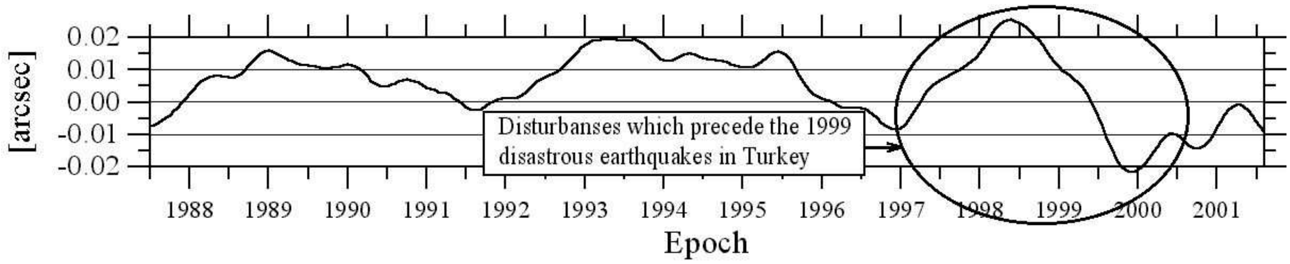

Figure 7. Long-period oscillation of the vertical at the Plana Observatory. The curve consists of one partial and one full cycles of oscillations with a period of about 5.5a and significant disturbances after 1997.0, which precede the 1999 disastrous earthquakes in Turkey

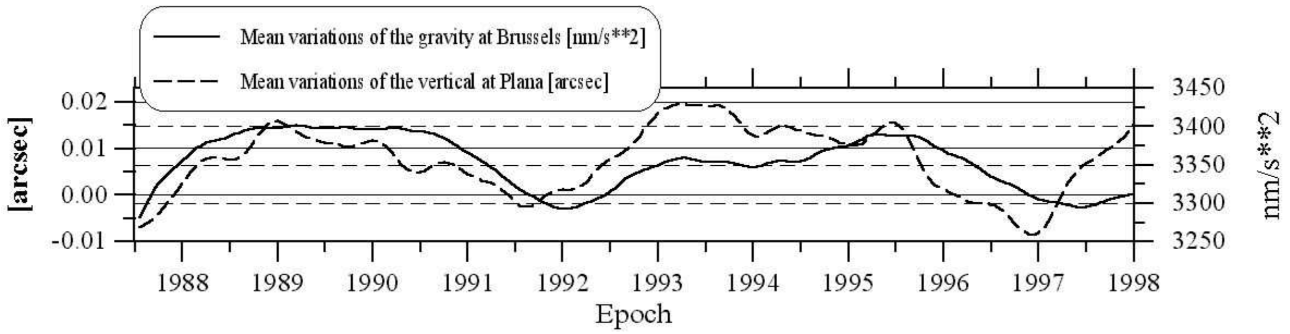

Figure 8. Comparison of the long-period oscillations of the gravity at the Brussels and the vertical of the Plana observatories for the period 1987.5–1997.5. Both samples of the curves consist of one partial and one full cycles of oscillation with a period of about 5.5 years and close phases

A GLOBAL GRAVITY LONG-PERIOD NONTIDAL OSCILLATION

The long-period oscillations of the vertical at the Plana Observatory (Fig. 7) consist of two cycles with a period of about 5.5a during 1987.5–1997.5 and strong disturbances after 1997.0, which precede the 1999 disastrous earthquakes in Turkey. The long-period behaviour of the oscillation of the vertical at the Plana Observatory during 1987.5–1997.5 is very similar to the oscillation of the gravity at the Brussels Observatory for the same period (Fig. 8). Both curves in Fig. 8 consist of two cycles of oscillation with a period of about 5.5 years and close phases. Here the first cycle is presented partially, its full length of 5.5a during the period 1986.5–1992.0 is seen in Fig. 4.

The correlation between the long-period nontidal variations of the gravity at Brussels and the vertical at Plana is very high. In the Table 1 several parts of the curves, which have significant coefficients of correlation in the interval 0.75÷0.92, are pointed out. Only short part of the curves between the epochs 1997.2 and 1994.0 does not agree satisfactory, due to a small local disturbing variation of the vertical at the Plana Observatory. As a result the correlation coefficient for the whole period decreases to the value 0.57.

Table 1. Coefficients of the correlation between the variations of the gravity at Brussels and the vertical at Plana for different periods

Period	Correlation	Period	Correlation
1987.5–1992.0	+0.92	1994.0–1997.2	+0.75
1987.5–1992.7	+0.80	1987.5–1997.2	+0.57

The distance between the Brussels and Plana observatories is more than 2000 km, therefore, the possible common reason for the presence of the two cycles of 5.5a oscillation with close phases has a global origin. Moreover, this common global reason affects as the value of the mean gravity acceleration (at the Brussels Observatory), as the direction of the gravity acceleration (or the vertical at the Plana Observatory). Thus, this investigation points out to a global gravity oscillation of the Earth with a period of 5.5 years. The value of this long-period gravity oscillation is approximately a half of the period of the solar activity, therefore, it is possible to investigate chain interconnections of the variations of the solar activity, changes of the atmosphere and ocean parameters, variations of the Earth gravity field and measured gravity values on the Earth surface.

CONCLUSIONS

1. The long-period variations of the gravity at the Brussels Observatory and the vertical at the Plana Observatory are high-correlated for the period 1987.5–1997.2.
2. Both samples of the time series consist of two cycles of oscillations with a period of about 5.5a and close phases. The amplitude of the long-period oscillation of the gravity at Brussels, determined by superconducting gravimetry measurements, is about 50 nm/s^2. The amplitude of the long-period oscillation of the vertical at Plana, determined by latitude observations, is 0.01 arcsec.
3. The long-period variations of the gravity at the Brussels Observatory and the vertical at the Plana Observatory have a common origin, due to a global gravity oscillation of the Earth with a period of 5.5 years.
4. The presented results prove the possibilities to use the combination of astronomical data and high-precise tidal data in the study of the time-variations of the Earth gravity field.

Acknowledgements. The work was supported by the National Council for Scientific Research at Ministry of Education and Science of Republic Bulgaria with the grant NZ-1205/02, also by the Organizing Committee of the MAO-2004 Conference "Astronomy in Ukraine – Past, Present and Future", Kiev, Ukraine, July 15–17, 2004.

[1] *Darakchiev Tz., Chapanov Ya.* Investigation of the nontidal changes of the vertical at Geodetic Observatory "Plana" by regular astronomical observations of geographic latitude // Proc. 3rd Balkan Geoph. Congr., Sofia, June 24–28, 2002.–2002.–P. 337–338.

[2] *Darakchiev Tz., Chapanov Ya.* Nontidal changes of the vertical at Geodetic Observatory "Plana" for the period July 1987– July 2001 // Geodesy.–2002.–**16**.–P. 71–80.