ACTIVITIES OF GRAVIMETRIC LABORATORY AT JÓZEFOSŁAW ASTRO-GEODETIC OBSERVATORY IN THE FRAME OF GEODYNAMIC INVESTIGATIONS

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1. INTRODUCTION

Installations of the absolute gravimeter FG5 No 230 in Astro-Geodetic Observatory at Jozefoslaw in June 2005 gave the possibility for the continuation of the gravity behaviour monitoring. The previous investigations were performed using ballistic (symmetric) gravimeter ZZG (Zbigniew Ząbek Gravimeter), constructed in Poland. The paper presents results of semi-annual interval of determinations of the gravity and geophysical phenomena appeared in non-tidal frequency bands. At the laboratory the tidal gravity measurements have also been performed since 2002 using LC&R ET-26 gravimeter. This elaboration also deals with the results of three and a half years cycle of gravimetric tidal observations adjustment. It also presents the influence of the environmental parameters (seasonal loading effects induced by air pressure and ocean, surficial water table, soil moisture and the rainfall as well) to the gravity changes.

2. GRAVIMETRIC LABORATORY

In 1996 Polish State Committee for Scientific Research decided to assign the founds for a new building of the Observatory. The construction ended in 2000. Several scientific laboratories were established and one of them was gravimetric laboratory placed in the Observatory's cellar, 6 m depth mostly to avoid microseimses (Fig. 1).

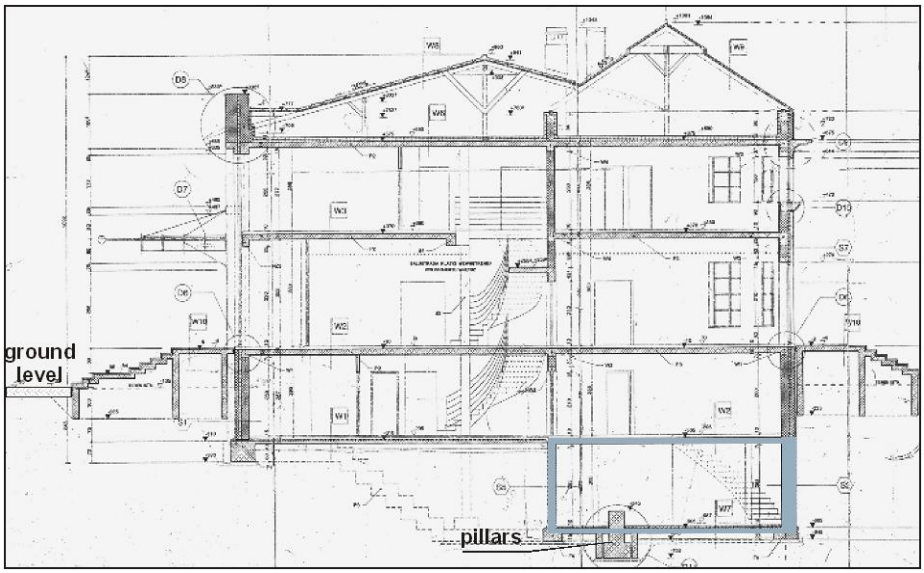

Fig. 1. Situation of the gravimetric laboratory at Józefosław Observatory

3. TIDAL GRAVITY DETERMINTIONS

Continuous tidal gravity measurements since January 2002 have been conducted using LaCoste&Romberg ET-26 gravimeter. The instrument is placed in the electronically controlled thermal chamber. Sampling rate is one minute with the time stability controlled by Internet. The data stored from 2002 are presented in Fig. 2.

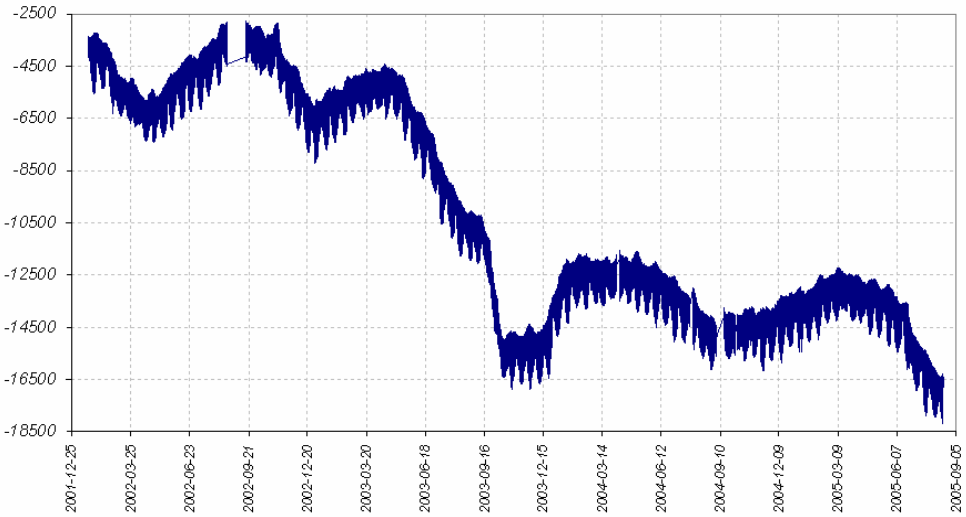

Fig. 2. Tidal gravimetric data [nm/s^2] obtained in Józefosław

The data adjustment of this data was made using ETERNA v. 3.4 (Wenzel, 1996). It shows that the accuracy is 8.4 nm/s^2, but if we divide the data into one-year blocks we obtained as follows:
$m_{0\ 2002}$ = 4.4 nm/s^2, $m_{0\ 2003}$ = 4.5 nm/s^2, $m_{0\ 2004}$ = 4.6 nm/s^2, $m_{0\ 2005}$ = 2.3 nm/s^2.
These accuracies are not comparable to the accuracies of superconducting gravimeters, but we have to point out that these observations are the most precise that were ever carried out in Poland. The results of tidal data adjustment are presented in Fig. 3 and 4.

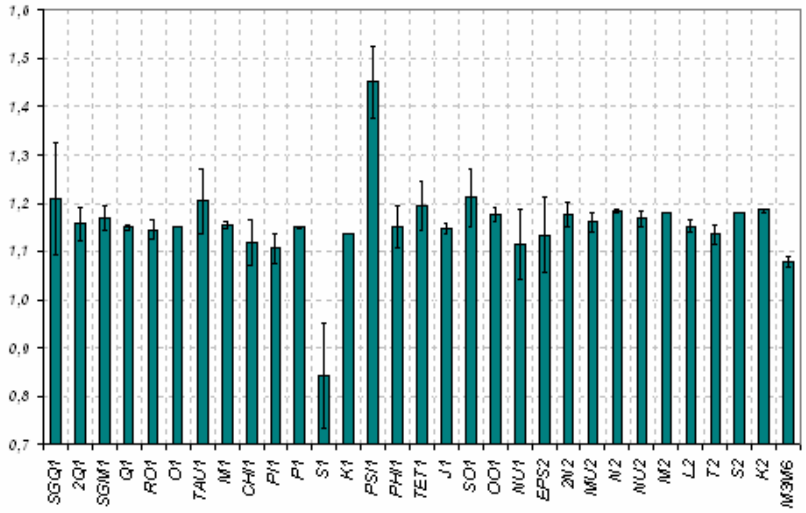

Fig. 3. Amplitude factor in tidal registration at Józefosław

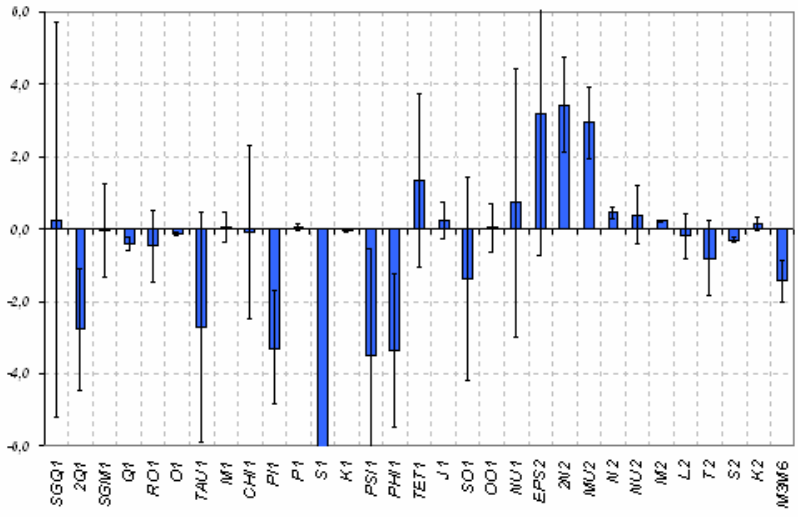

Fig. 4. Phase shift [°] in gravimetric tidal registration

4. ABSOLUTE GRAVITY MEASUREMENTS AT JÓZEFOSŁAW

The absolute ballistic gravimeter FG5 No. 230 has been installed at Jozefoslaw observatory in June 2005. Situation in a vicinity of the gravimetric station in Fig. 5 is presented.

Fig. 5. FG5 No 230 gravity meter on station in Józefosław

From this time the repeated gravity measurements regularly once a month have started. Standard procedure of measurement embraces 24 hours cycle with 24 sets. Typically *g* value is obtained from 2400 drops. Gravity station in Jozefoslaw Observatory offers good stability, so precision of a single drop is ca. 7 - 8 μGal. This precision makes possible to obtain 2 μGal precision of final *g* value, with about 1 μGal set scatter.
The raw values of *g* are corrected by following terms:

- **elastic earth tides (ETGTAB procedure) with common standard coefficients;**
- **barometric effect on gravity;**
- **polar motion influence on gravity;**
- **ocean mass loading;**

and referred on 100 cm level above pillar. The changes of gravity obtained in Józefosław by absolute determinations are presented in Fig. 6.

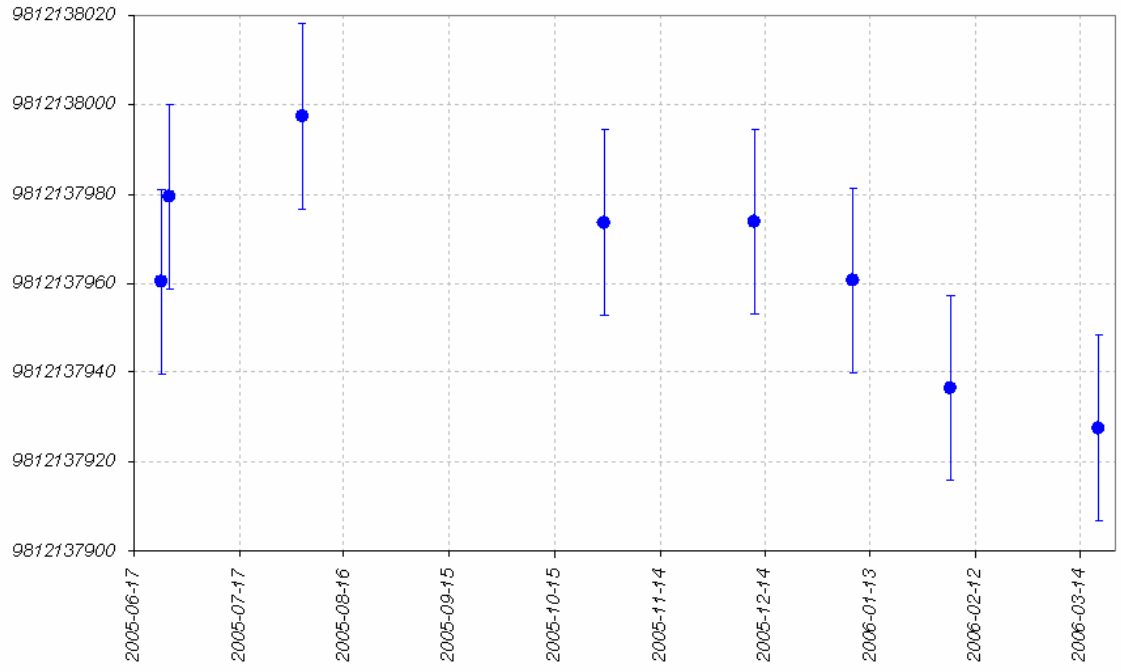

Fig. 6. Changes of absolute gravity [nm/s^2] at Józefosław station

5. OTHER OBSERVATIONS SUPPORTING GRAVIMETRICAL DETERMINATIONS

Simultaneously with the gravity changes we monitor and determine influence of the environmental conditions. The following supporting observations are conducted:

- **ambient pressure, temperature and humidity;**
- **soil moisture;**
- **rainfalls volume;**
- **depth of the ground water table;**
- **snow coverage thickness.**

5.1. Ambient pressure, temperature and humidity

Results of supporting observations conducted in Józefosław together with gravimetric observations are presented in Fig. 7, 8, 9 and 10.

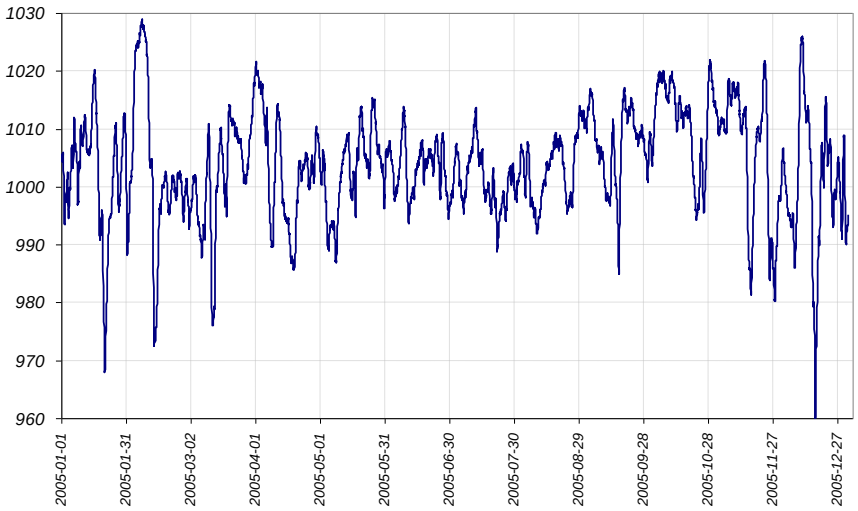

Fig. 7. Changes of ambient pressure [hPa] in 2005 at Józefosław Observatory

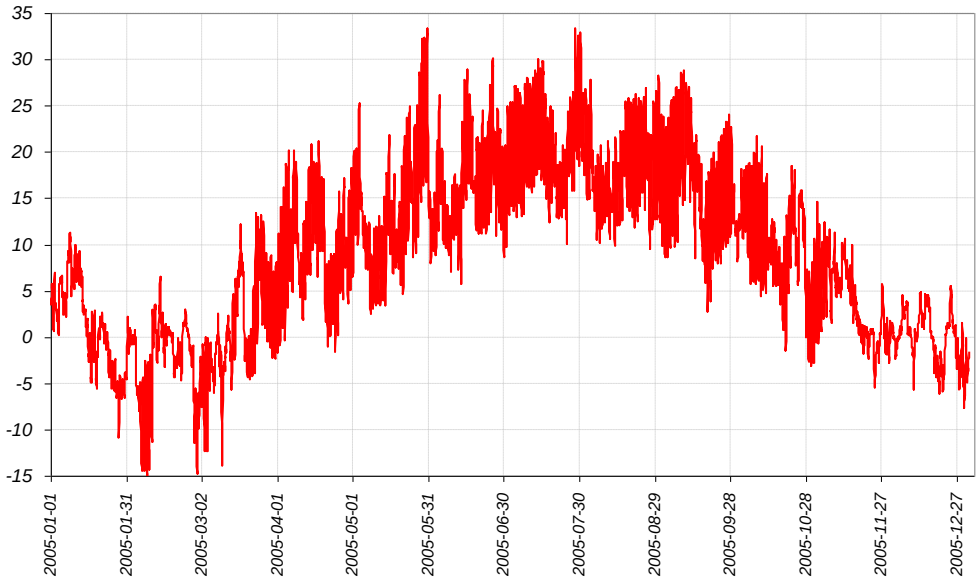

Fig. 8. Changes of ambient temperature [°C] registered in Józefosław at 2005

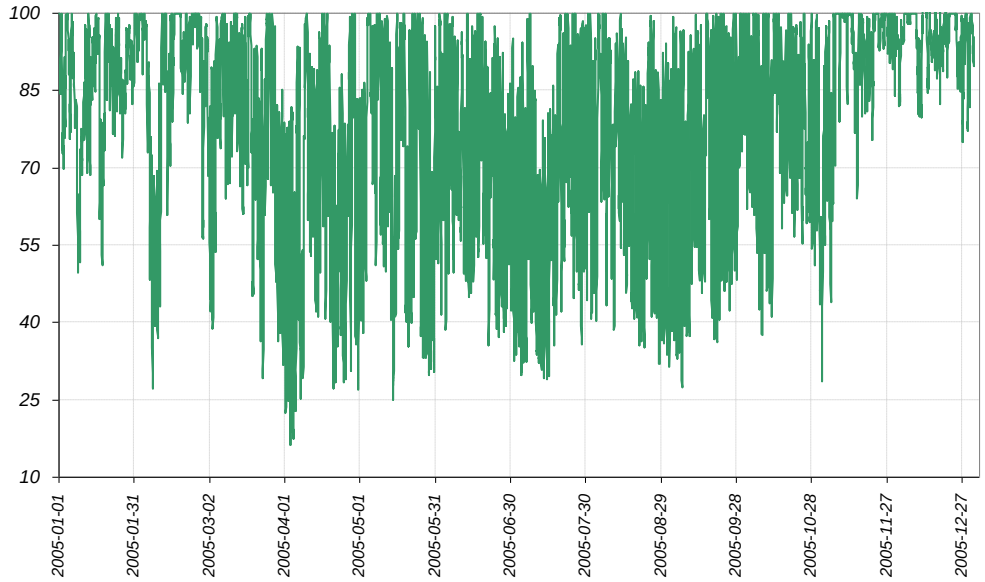

Fig. 9. Changes of ambient humidity [%] at Józefosław in 2005

The effects of the atmospheric influence to the gravity and elastic deformation of the Earth crust calculated using single regression coefficient determined in previous investigations (Bogusz, 2000) have been obtained by formulae:

$$\begin{aligned} \Delta g\left[nm/s^2\right] &= -3.450 * \Delta p[hPa] \\ \Delta u[mm] &= 0.3575 * \Delta p[hPa] \end{aligned} \tag{1}$$

and presented in Fig. 10.

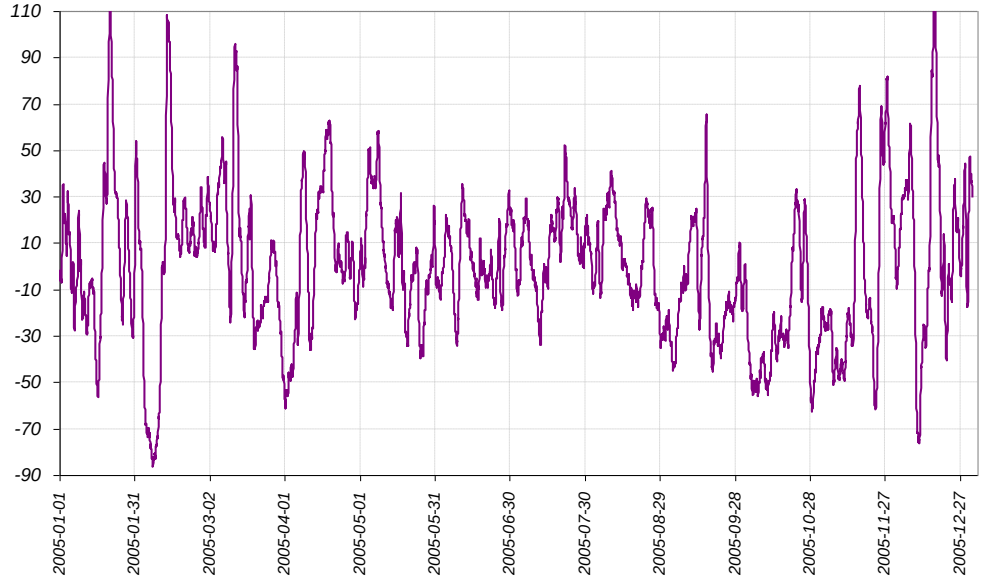

Fig. 10. Changes of atmospheric gravity effect [nm/s^2] in Józefosław at 2005

5.2. Groundwater level observations

The ground in a vicinity of the Observatory is composed mostly of the sand and clay as it is presented by geological section given in Fig. 11.

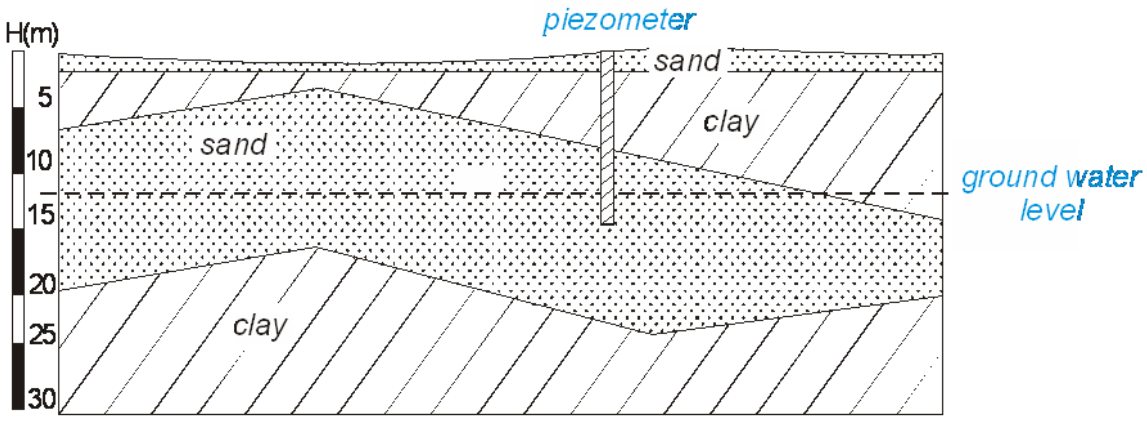

Fig. 11. Geological section in the vicinity of piezometer in Józefosław

This is not very comfortable situation because clay keeps water. The especially installed piezometer to observe changes of water level is placed near the building of the Observatory to make the proper correction due to these changes. The Fig. 12 presents the changes of the water table in 2005.

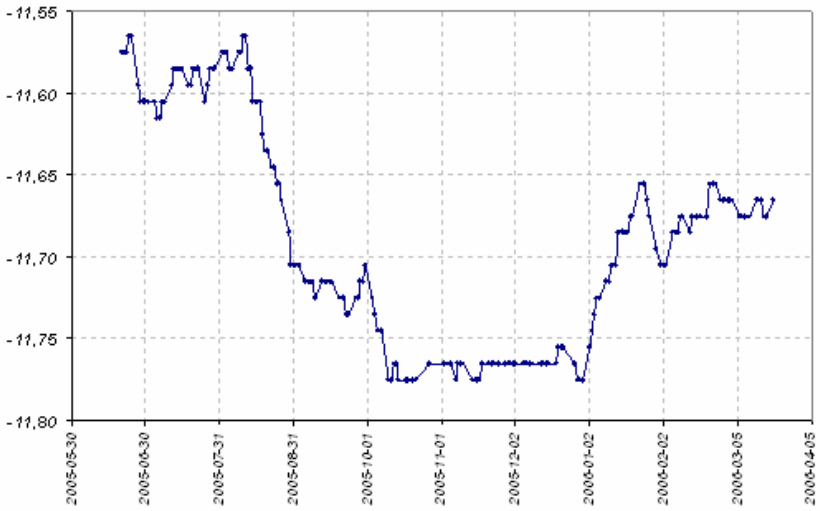

Fig. 12. Changes of the water table [m] observed by piezometer in 2005

Using the equation derived from the previous papers (Barlik et al., 1989), namely:

$$\Delta g\,[\mathrm{nm/s^2}] = 102.7 \cdot \Delta H\,[\mathrm{m}] \qquad \textbf{(2)}$$

we obtained the gravity changes due to water level changes as presented in Fig. 13.

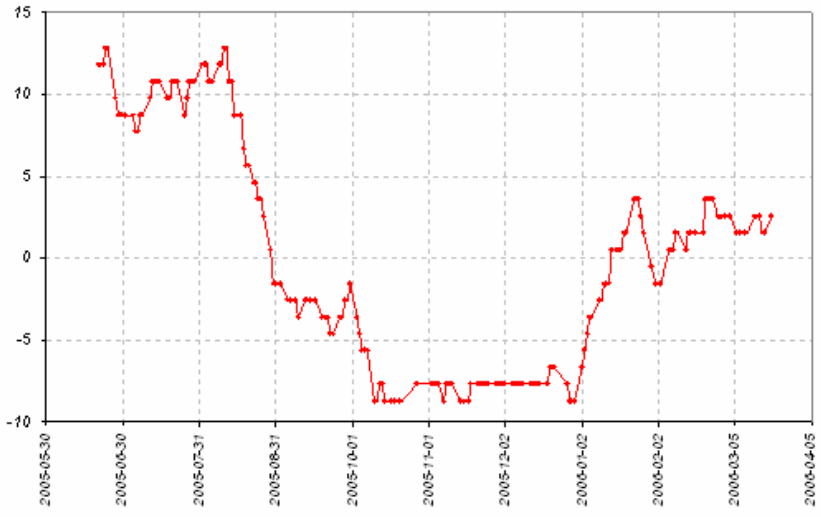

Fig. 13. Changes of the gravity [nm/s^{-2}] due to the water level changes in Józefosław

5.3. Soil moisture determinations

In 2005 we have executed the test measurements of the soil moisture changes at two stands at 0.5 m depth, placed near gravimetric station, which are presented in Fig. 14. It ought to be mentioned that we plane to put in 2006 sensors to measure the soil moisture continuously.

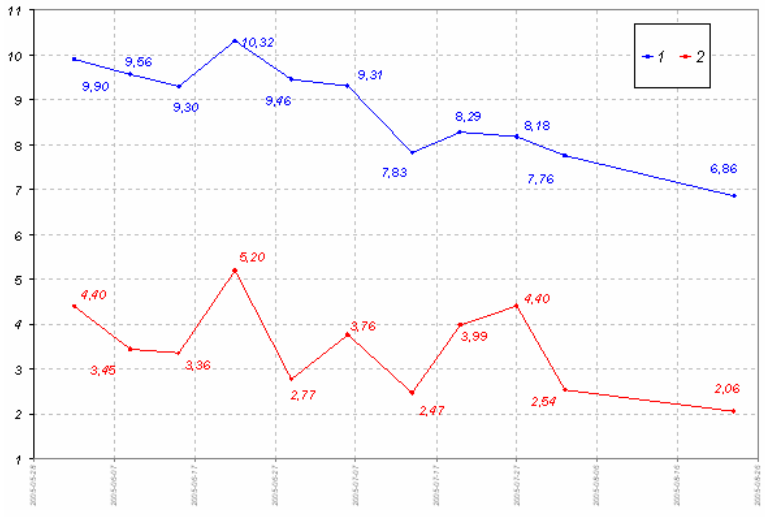

Fig. 14. Soil moisture changes [%] observed in Józefosław during 2005

5.4 Changes of precipitation

In 2005 an analog instrument for rainfalls measurements were installed in the Observatory to make test observations. In Fig. 15 the results of these determinations are presented. We also plan to establish permanent recordings of the precipitation.

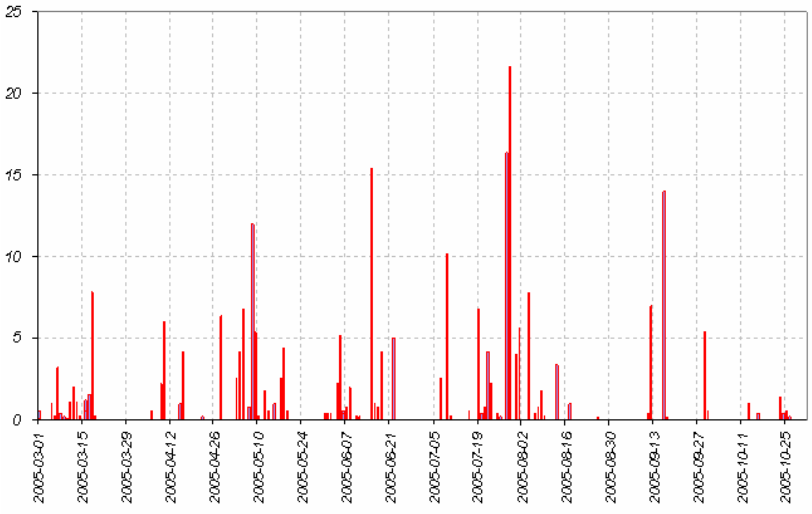

Fig. 15. Changes of precipitation in 2005 [mm] obtained in Józefosław

5.5 Snow coverage observations

During winter measurements we have also monitored the thickness and density of the snow coverage around the observatory building. We considered that the slow drift of the gravity which can be clearly seen in Fig. 6 can be explained in 90% by snow and ground water gravitational influence.

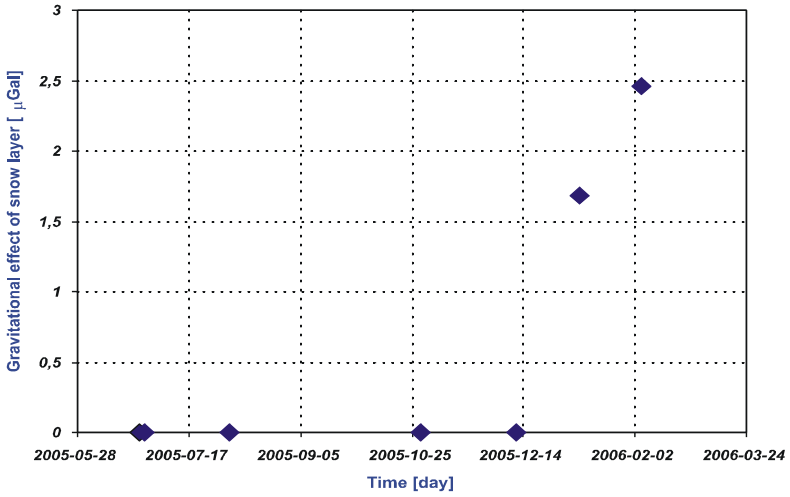

Fig. 16. Gravitational effect of a snow layer at Jozefoslaw

6. SIMULTANOUS GRAVITY OBSERVATIONS

Before the ET gravimeter breakdown we have made three simultaneous determinations of gravity using that instrument and also the absolute FG5 gravimeter. Fig. 17 shows that the ET is quite well calibrated, however the work on calibration will be done in a near future.

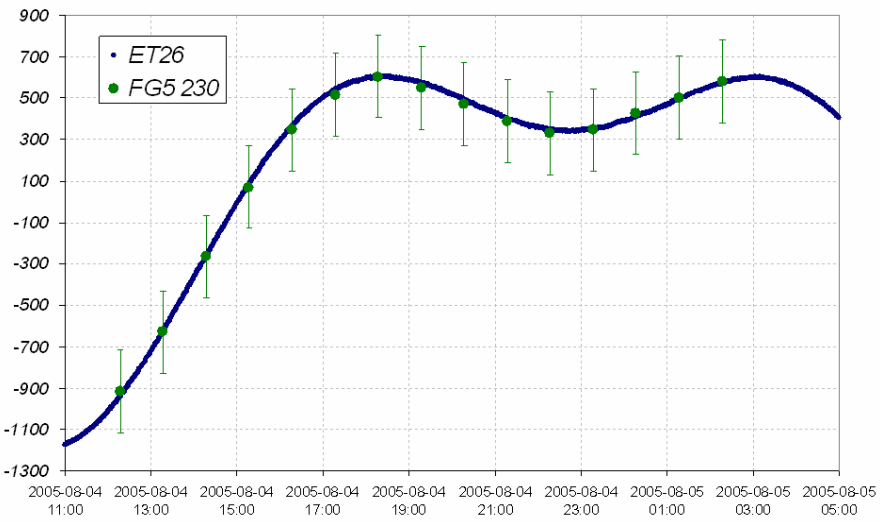

Fig. 17. Results of the simultaneous absolute and relative gravimetric observations

7. CONCLUSIONS AND PLANS FOR FUTURE

The paper presents a situation conditions in the Astro - Geodetical Observatory at Józefosław and possibilities in the field of gravity changes monitoring there using the absolute gravimeter as well as gravimetric tide registration. Authors pressume that our gravimetrical laboratory supplies good conditions for localisation there the comparision centre for absolute gravimeters in the region of Central and Eastern Europe. The monitoring of gravitational effects of geophysical phenomena gives possibility to improve gravimetric determinations and to compare them from epoch to epoch as well.

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