PLANS FOR GRAVIMETRIC MEASUREMENTS
AT JOZEFOSLAW OBSERVATORY

Marcin Barlik, Janusz Bogusz, Tomasz Olszak

Institute of Geodesy and Geodetic Astronomy, Warsaw University of Technology

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, 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).

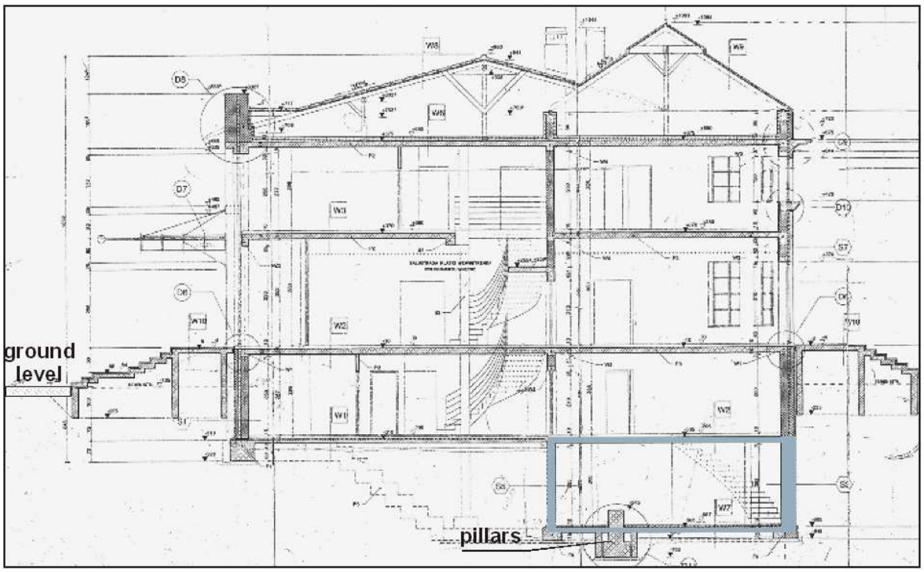

Fig. 1. Gravimetric laboratory at Jozefoslaw Observatory.

3. TIDAL GRAVITY MEASUREMENTS

Continuous tidal gravity measurements have been conducted since January 2002 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.

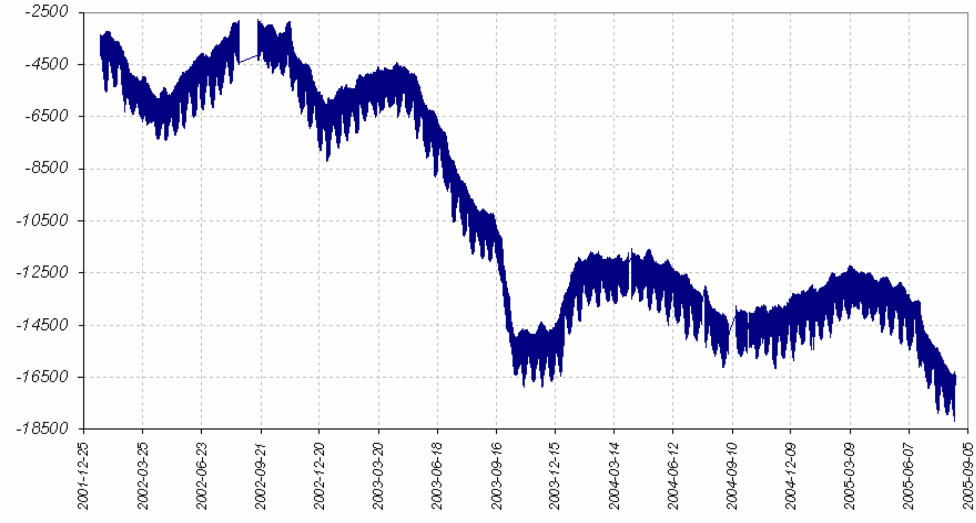

Fig. 2. Tidal data [nm/s^2].

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:

$m_{0\ 2002}$ = 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.

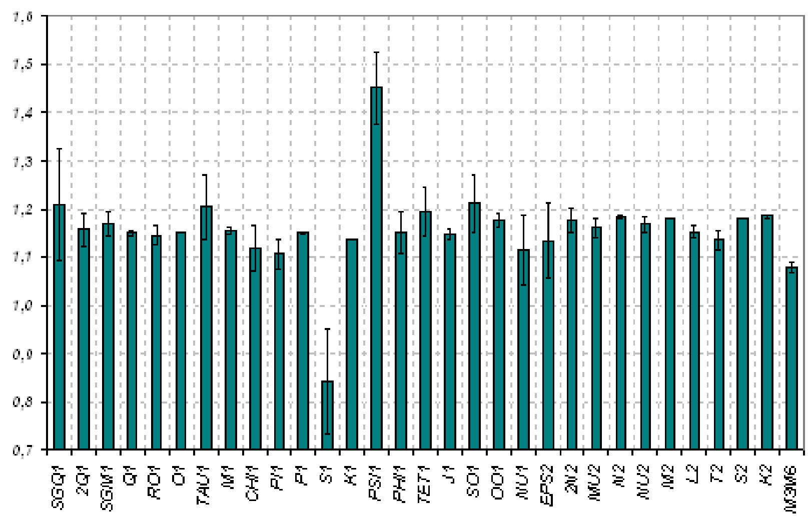

Fig. 3. Amplitude factor.

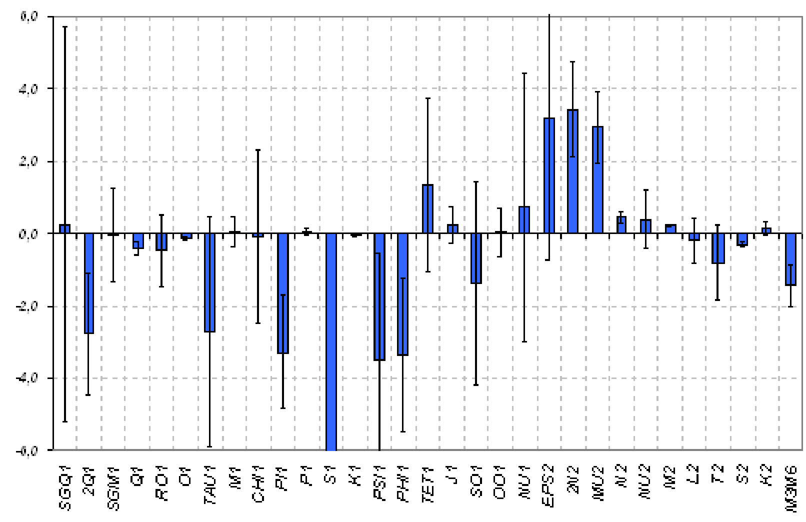

Fig. 4. Phase shift [°].

4. ABSOLUTE GRAVITY MEASUREMENTS

The absolute gravimeter FG5 No. 230 has been installed at Jozefoslaw observatory in June 2005.

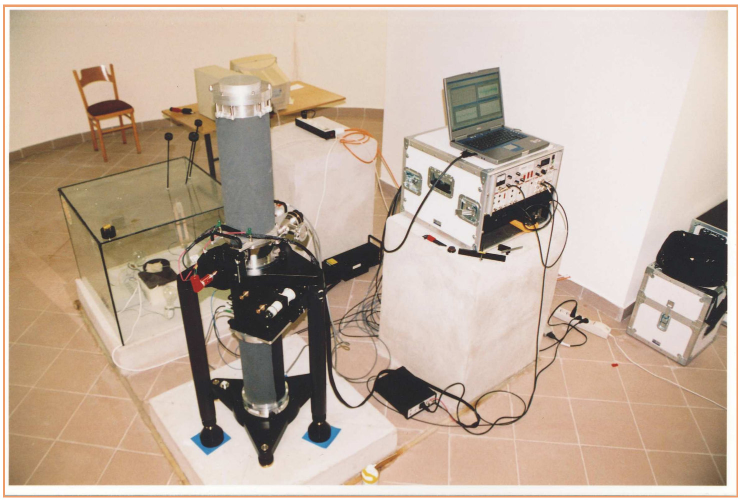

Fig. 5. FG5 No 230 gravity meter in Jozefoslaw.

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:

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

and referred on 100 cm level above pillar. The changes of gravity are presented in fig. 6.

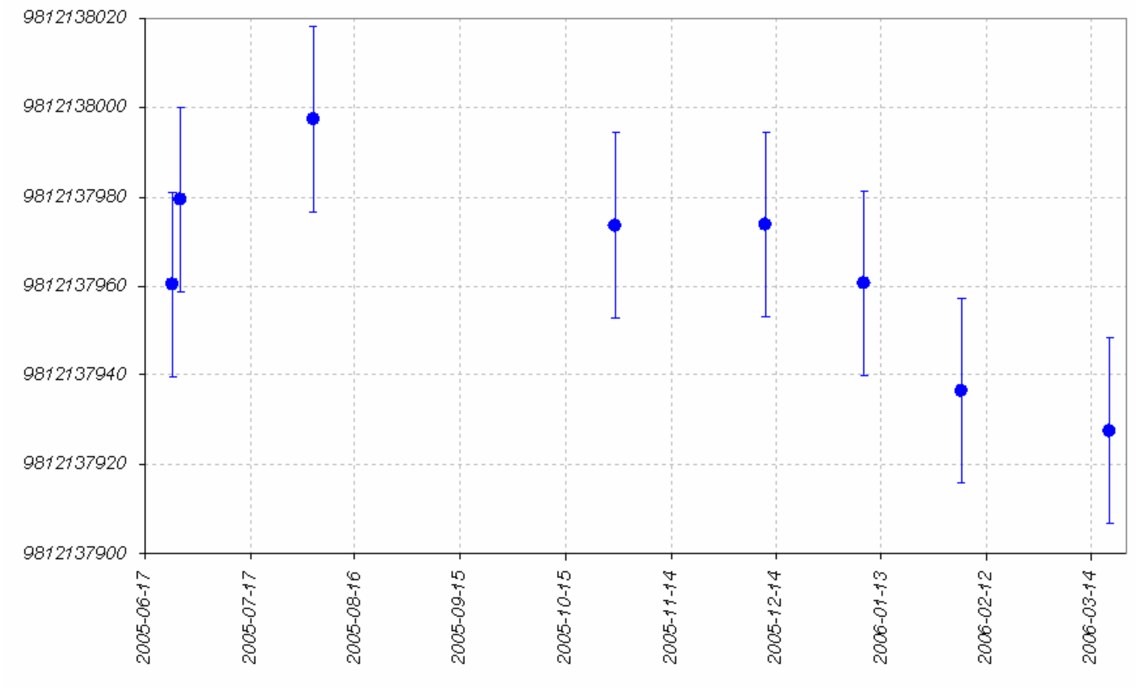

Fig. 6. Changes of gravity [nm/s^2].

5. SUPPORTING OBSERVATIONS

Together with the gravity changes we monitor and determine influence of the environment. The following supporting observations are conducted:

- **ambient pressure, temperature and humidity;**
- **soil moisture;**
- **rainfalls;**
- **ground water table;**
- **snow coverage.**

5.1. Ambient pressure, temperature and humidity

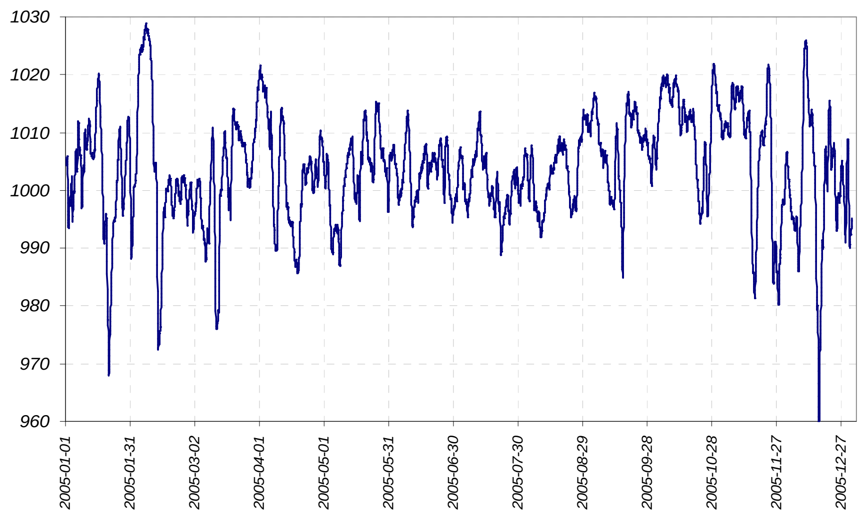

Fig. 7. Changes of ambient pressure [hPa] in 2005.

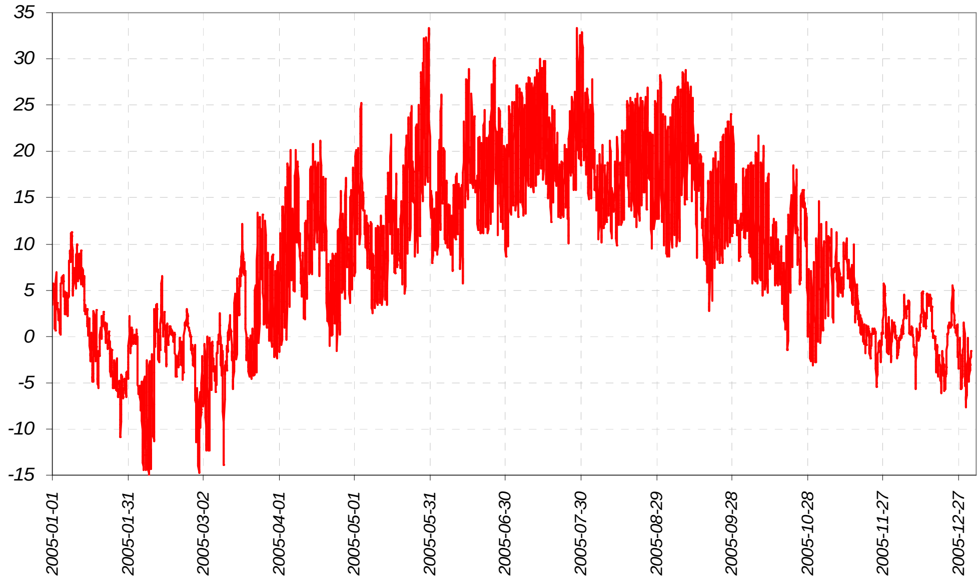

Fig. 8. Changes of ambient temperature [°C] in 2005.

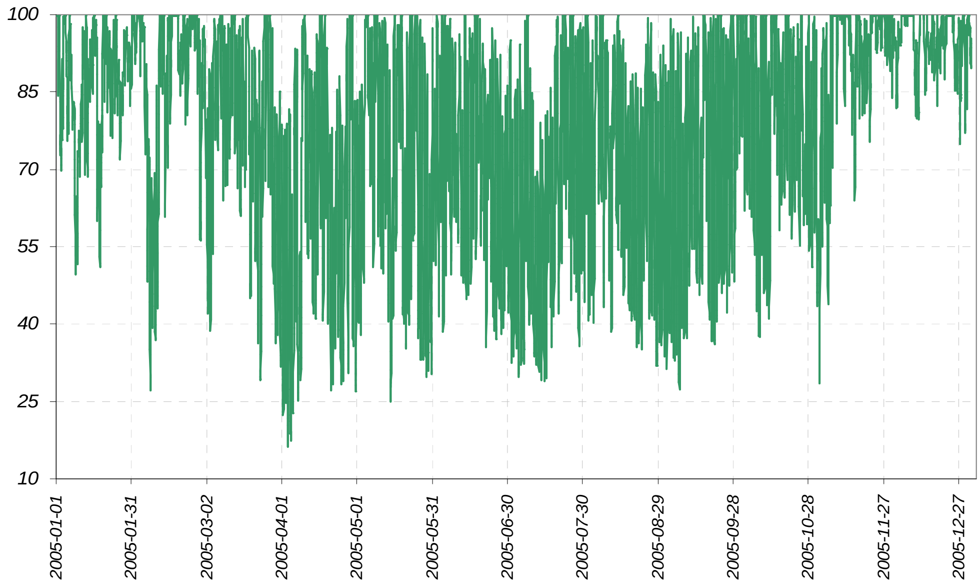

Fig. 9. Changes of ambient humidity [%] in 2005.

The effect of the atmospheric influence to the gravity calculated using single regression coefficient determined in previous researches (Bogusz, 2000):

$$\Delta g\left[nm/s^2\right] = -3.450 * \Delta p\left[hPa\right]$$
$$\Delta u\left[mm\right] = 0.3575 * \Delta p\left[hPa\right] \quad \textbf{(1)}$$

are presented in fig. 10.

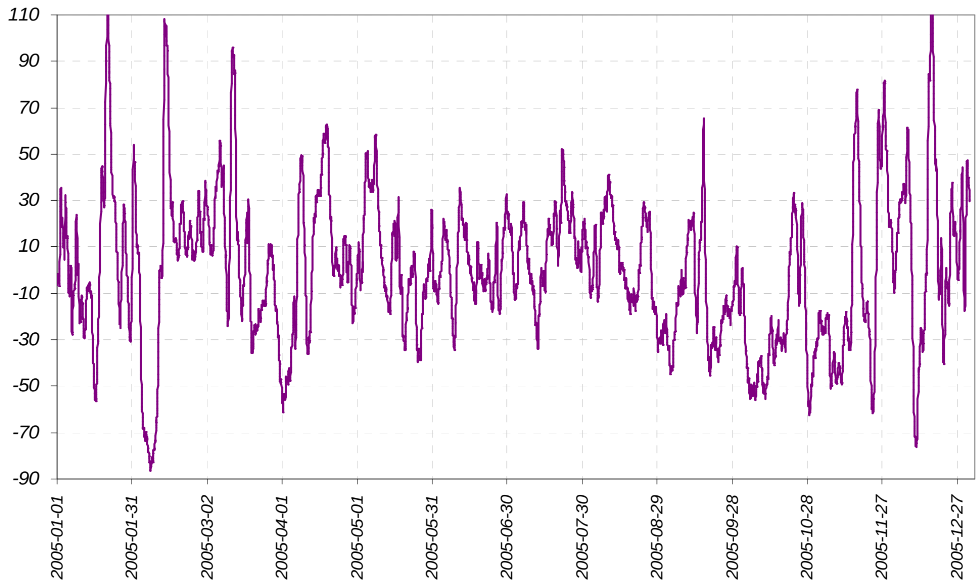

Fig. 10. Changes of atmospheric gravity effect [nm/s^2] in 2005.

5.2. Groundwater level observations

The ground at the Observatory is composed mostly of the sand and clay (fig. 11).

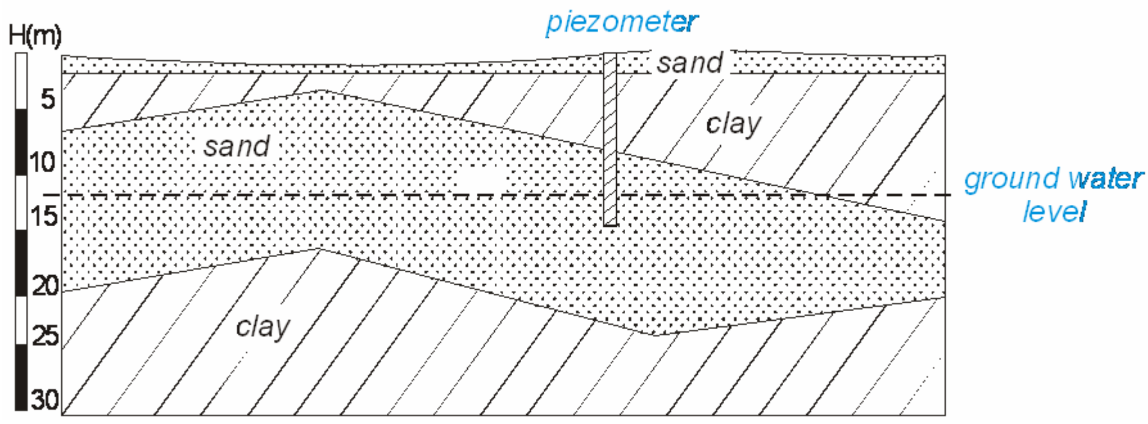

Fig. 11.

This is not very comfortable situation because clay keeps water. The 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.

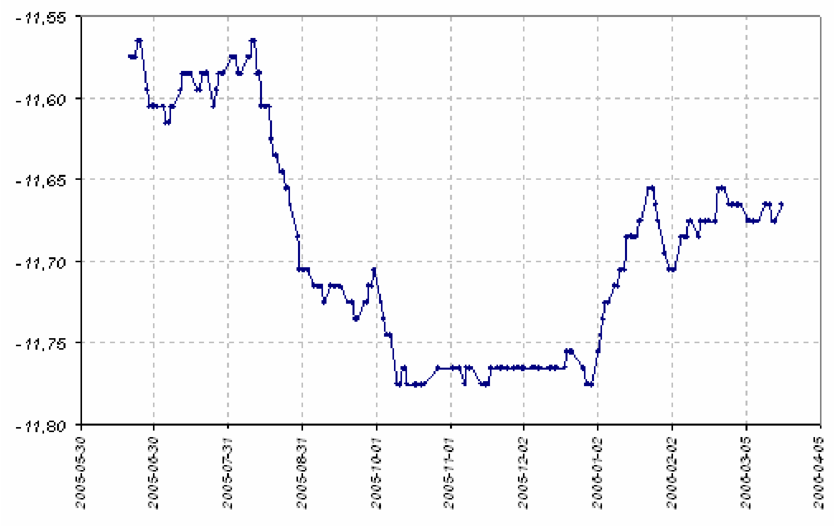

Fig. 12. Changes of the water table [m] observed in 2005.

Using the equation derived from the previous researches (Barlik at. al., 1989):

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

we obtained changes of the gravity due to water level changes (fig. 13).

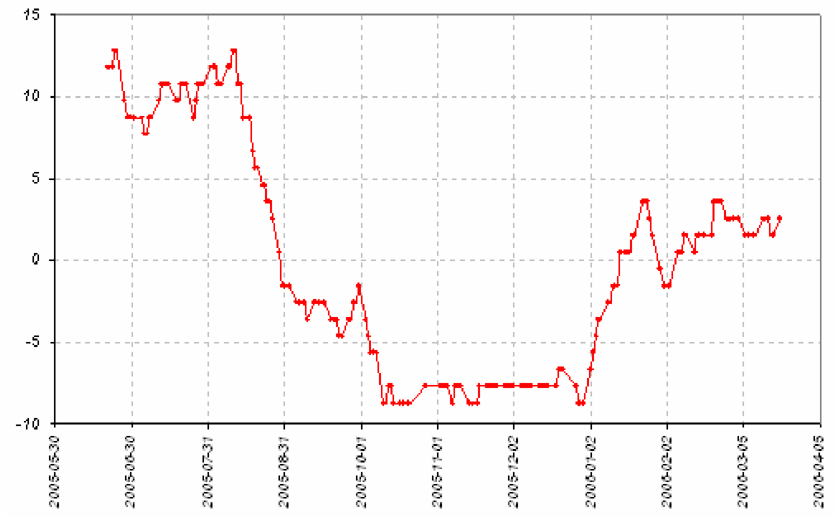

Fig. 13. Changes of the gravity [nm/s^2] due to the water level changes.

5.3. Soil moisture determinations

In 2005 we have made the test measurements of the soil moisture changes at two points at 0.5 m depth, which are presented in fig. 14. We plane to put in 2006 sensors to measure the soil moisture continuously.

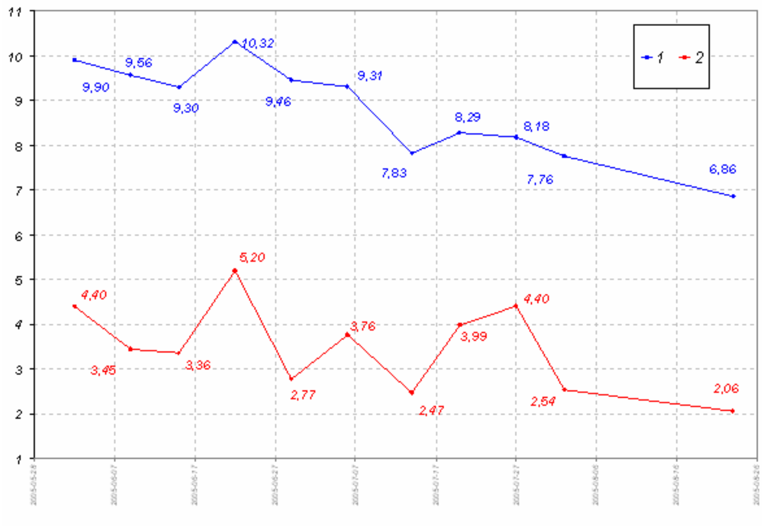

Fig. 14. Soil moisture changes [%] observed in 2005.

5.4 Changes of precipitation

In 2005 analog instrument for rainfalls measurements were put in the Observatory to make test measurements (fig. 15). We also plan to establish permanent recordings of the precipitation.

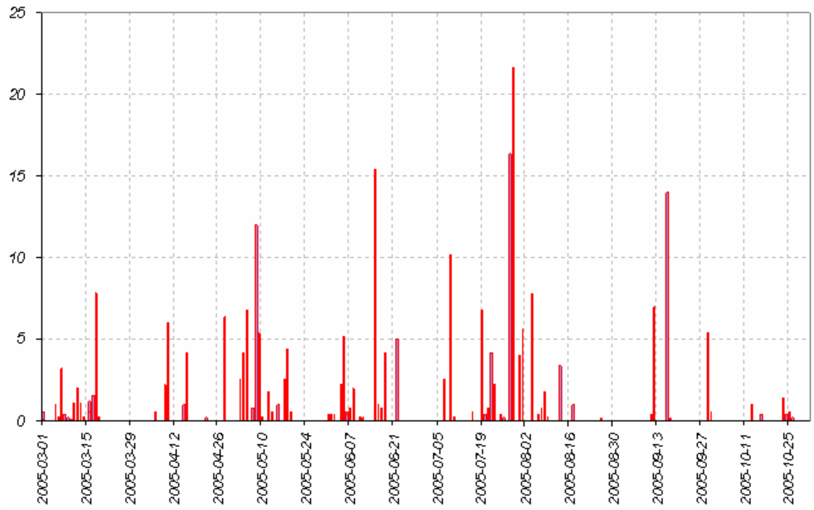

Fig. 15. Changes of precipitation in 2005 [mm].

5.5 Snow coverage observations

During winter measurements we have also monitored the height and density of the snow coverage. We considered that the slow drift of the gravity which can be clearly seen in fig. 6 can be explained by snow and ground water influence.

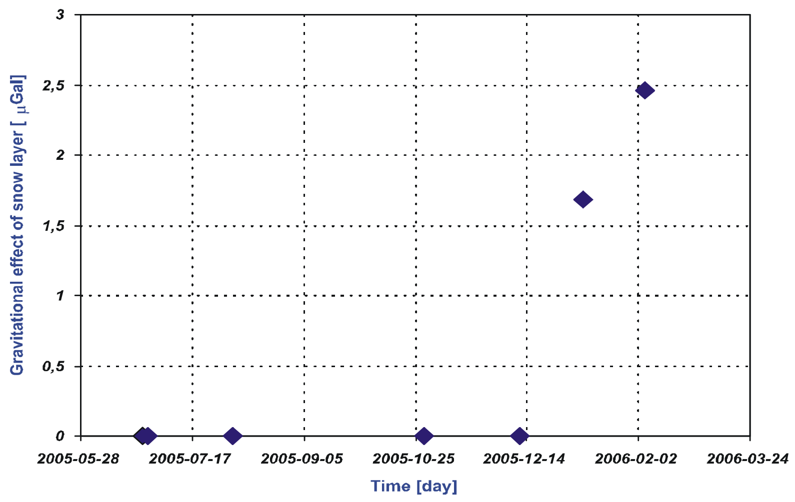

Fig. 16: Gravitational effect of a snow layer at Jozefoslaw.

6. SIMULTANOUS GRAVITY OBSERVATIONS

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

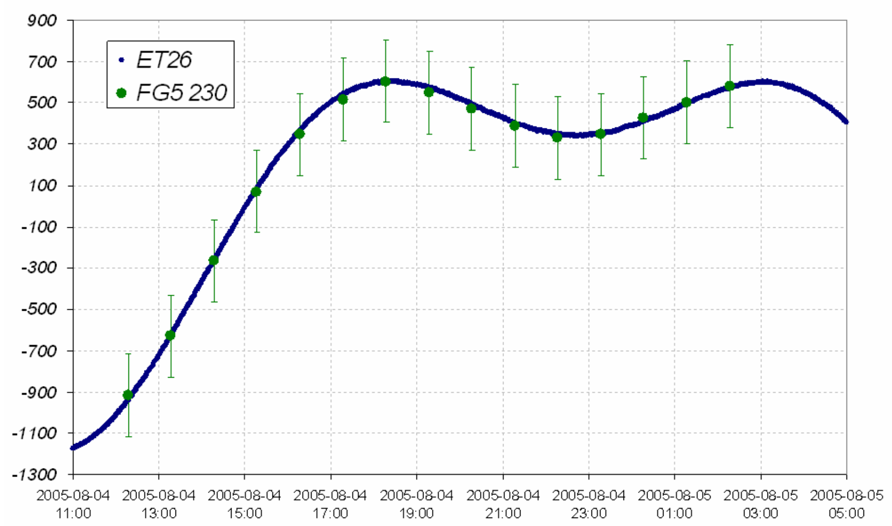

Fig. 17. Simultaneous gravity observations.

9. CONCLUSIONS AND PLANS FOR FUTURE

The paper presents a situation conditions in the Astro-Geodetic Observatory at Jozefoslaw and possibilities in the field of gravity changes monitoring there using the absolute gravimeter as well as gravimetric tide registration. Authors presume that our gravimetrical laboratory supplies good conditions for localisation there the comparison 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.

BIBLIOGRAPHY

1. **Barlik M., Rogowski J. B. (1989): „Variation of the Plumb line Direction Obtained from Astronomical and Gravimetric Observations”. Prace Naukowe PW. Geodezja z. 33, 1989.**
2. **Bogusz J. (2000) – “Investigation of Atmospheric Influence to the Gravimetric Tidal Observations”. Ph. D. Thesis.**
3. **Wenzel H.-G. (1996): „ETERNA 3.30. Earth Tide Data Processing Package”. Operation Manual.**