

Reading jumps of HGI-1 Scintrex CG-3M gravimeter

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ABSTRACT: *Continuous measurements with two Scintrex CG-3M gravimeters are made on the 16th floor of the building. One of them has reading jumps. Connection between reading jumps and change of the rate of micro seismic inside the building is determined. To analyze the problem deeper, measurements on the point with low micro seismic and after that again on the 16th floor were made. Vertical component of the micro seismic behavior of the building can be judged using standard deviations of the readings. Scintrex CG-3M gravimeter can be used to judge dynamic of the building.*

Key words: *reading jumps (tare), micro seismic, standard deviations of readings, tilts, dynamic of the building.*

1. Introduction

Reading jump (tare) is problem that is recognized by gravimetric community and about that problem can be found also in classical gravimetry textbooks as Torge (1989). This problem is solved on instrument individual basis, and only general definition can be found. To detect the problem, in the most cases, additional measurements are needed. Reading jumps (tare) are in the most cases connected to instrumental problems, but in this work will be presented problem with reading jumps of HGI-1 Scintrex CG-3M gravimeter that is caused by changing measurement conditions on the station. From this example behavior of Scintrex CG-3M gravimeter can be experienced. That can help us to understand behavior and characteristic of the instrument.

By Scintrex gravimeters cause of the reading jumps can be electronic or mechanical problems (Brèià 2002). By electronic problems gravimeter should be repaired, but by mechanical problems reading jumps can be influenced by the way how instrument is operated. Scintrex gravimeters do not have dumping system, measurements sensor is free all the time and in the most cases mechanical stress in the fieldwork are causing reading jumps. Mechanical resonance of the sensor caused by outside frequencies source can also cause reading jumps.

2. Definition of the problem

Continuous static measurement were made with two Scintrex CG-3M gravimeters; marked as HGI-1 and HGI-2. Measurements were done on the 16th floor of the skyscraper. On the Figure 1 can be seen that gravimeter HGI-1 has reading jumps that happen in rather regular periods. In about 7 a.m. jumps are positive and in about 7 p.m. jumps are negative. As it can be seen from Figure 1, that is happening regularly. But, simultaneous measurements of the HGI-2 gravimeter do not have jumps in the readings.

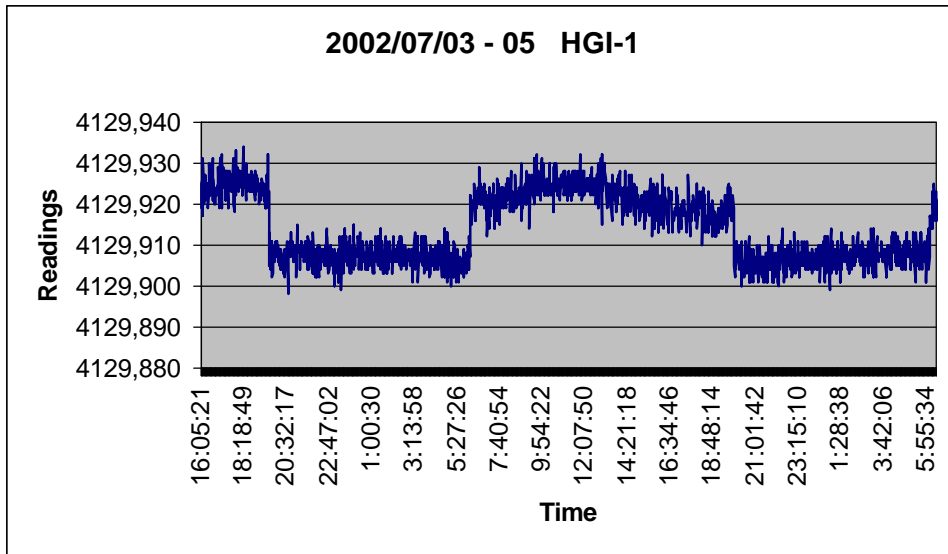


Figure 1. Readings of the HGI-1 in the period from July 3 to 5, 2002.

Building, where the measurements are made, is made of three skyscrapers with different heights and construction is rather complicated. The skyscrapers have dynamic behavior.

Scintrex CG-3M gravimeter is giving standard deviation for every reading. On the Figure 2 standard deviations for measurements on the Figure 1 can be seen. Changing of the micro seismic rate can be clearly recognized. The same behavior of the standard deviations can be recognized also in measurements with other gravimeter. That is making clear that this kind of behavior is connected to site, and it is not caused by instrument. During the working time, when building is crowded with people, micro seismic is significantly higher than in the other part of the day. Man-made micro seismic has specific frequencies (Ruymbeke 2002). Behavior of higher micro seismic rate is connected with working time in building and is caused by man made artificial micro seismic. That is showing that readings standard deviations of Scintrex CG-3M gravimeter is highly influenced by micro seismic and they do not describe stochastic behavior of the readings.

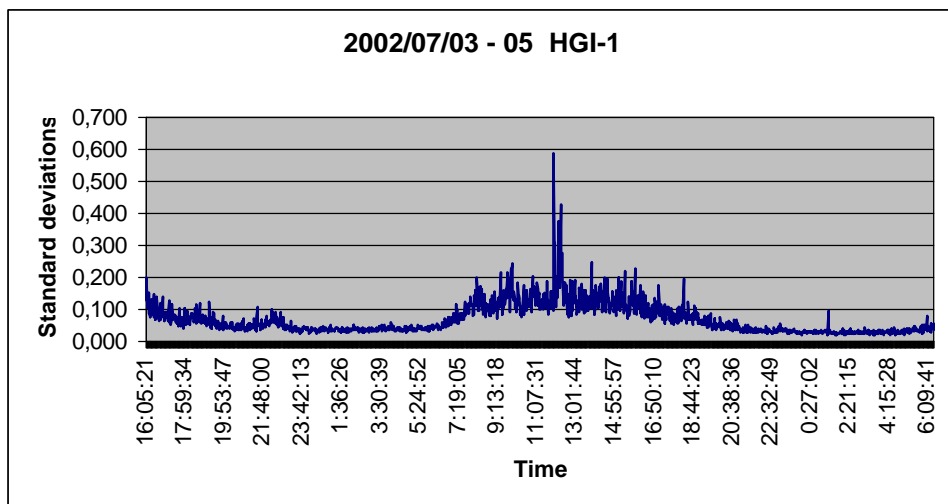


Figure 2. Standard deviations of the HGI-1 readings in the period from July 3 to 5, 2002.

3. Solution of the problem

To find more about problem, longer continuous static measurements were done on the same site. On the Figure 3 readings of the HGI-1 gravimeter in period from June 14 to 28, 2002 are given. Reading jumps can be clearly recognized. But, as can be seen, reading jumps do not happen every day. They do not happen on Saturday, Sundays and holidays. On that days micro seismic of the building is low. That is confirming that jumps are connected to micro seismic behavior of the building.

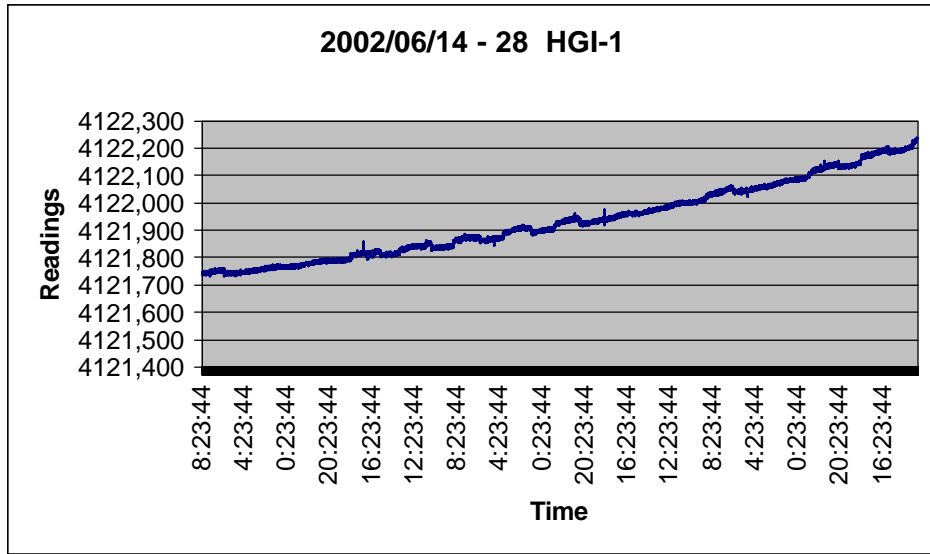


Figure 3. Readings of the HGI-1 gravimeter in the period from June 14 to 28, 2002.

On the Figure 4 standard deviations of the readings on the Figure 3 can be seen.

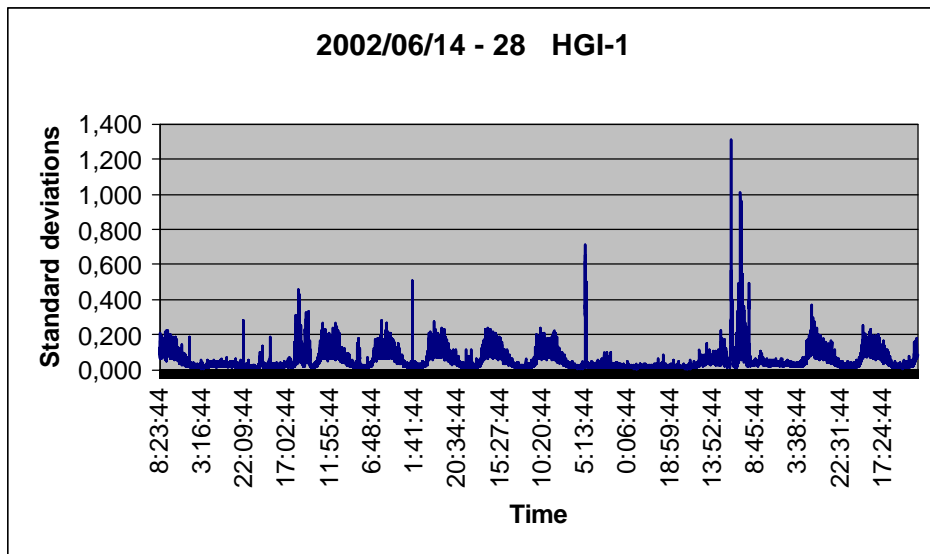


Figure 4. Standard deviations of the HGI-1 readings in the period from June 14 to 28, 2002.

Daily changes of the man made micro seismic influence can be clearly recognized. Signal of standard deviations is giving the view in building dynamic.

The building has daily tilt that can be measured with Scintrex CG-3M tilt sensor. On the Figure 5 daily tilts can be clearly recognized. Tilt behavior of the building is not reason for reading jumps because tilts are happening regularly every day and jumps are not happening on the not working days. It can be only additional factor to micro seismic that cause reading jumps.

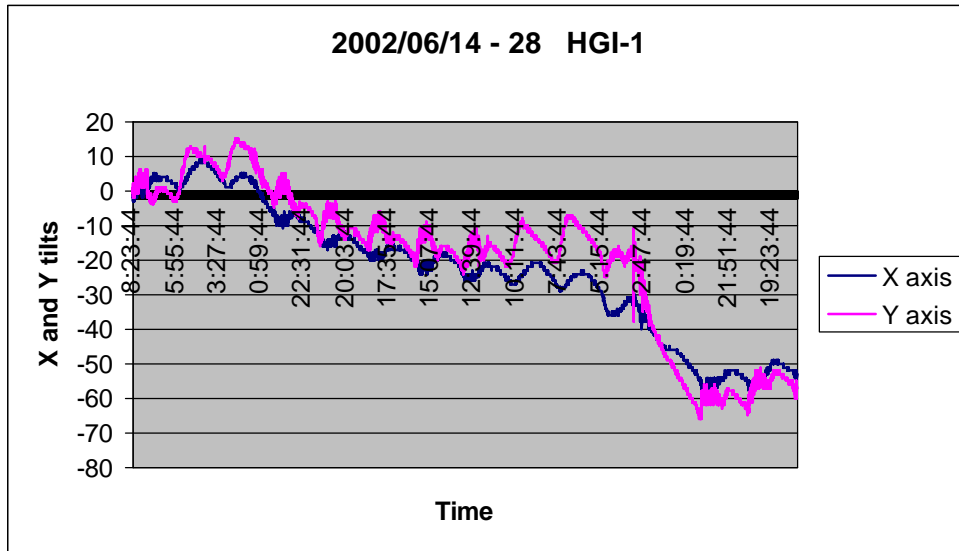


Figure 5. Tilts of X and Y axes of the HGI-1 in the period from June 14 to 28, 2002.

On the Figures 6 and 7 are presented signals for temperature and from gravimeter Earth tides correction. That signals are behaving normally.

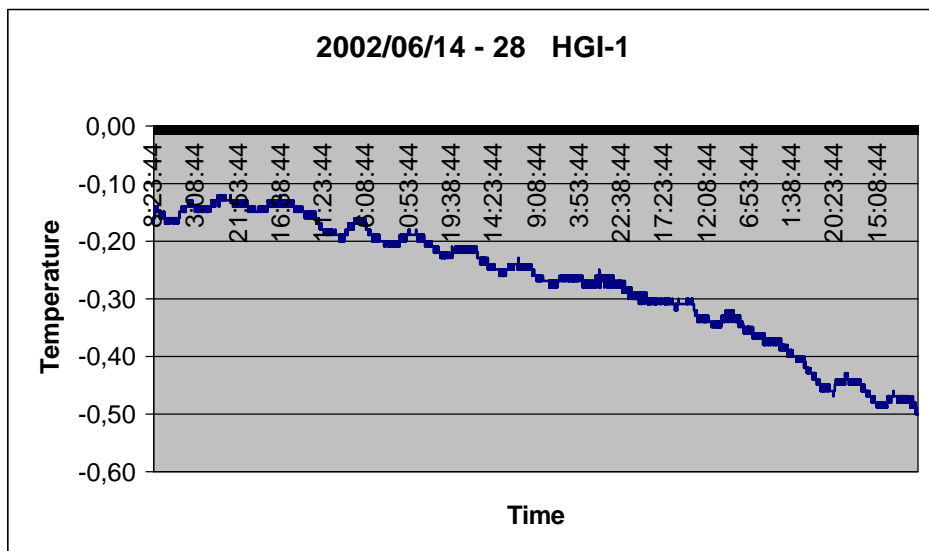


Figure 6. HGI-1 temperature in the period from June 14 to 28, 2002.

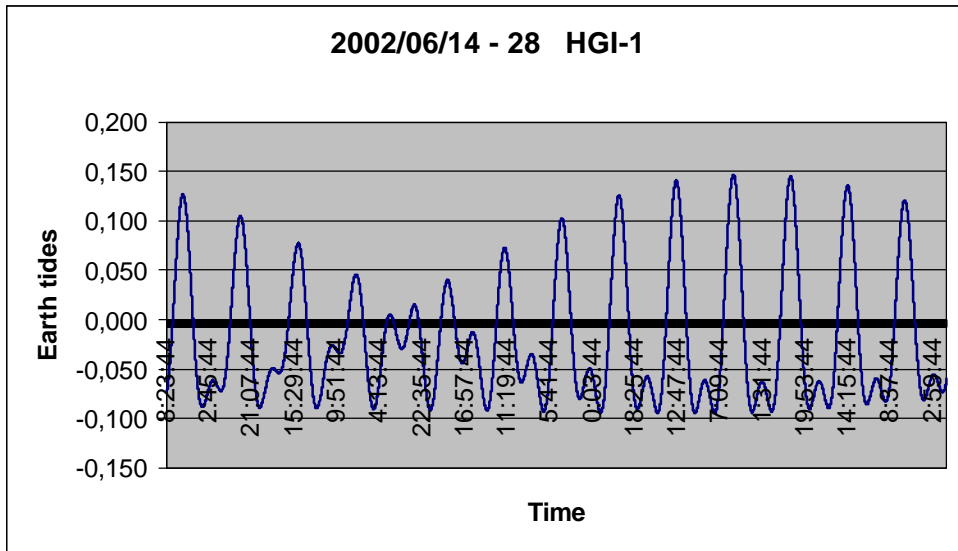


Figure 7. Earth tides corrections from gravimeter HGI-1 in the period from June 14 to 28, 2002.

From this measurement is more clear that reading jumps are connected to change of micro seismic rate in the building, but they do not happen on Saturdays, Sundays and holidays.

Simultaneous measurements are made with the HGI-2 gravimeter. On the Figure 8 reading of the HGI-2, in period from June 12 to 28, 2002 can be seen. Readings do not have jumps.

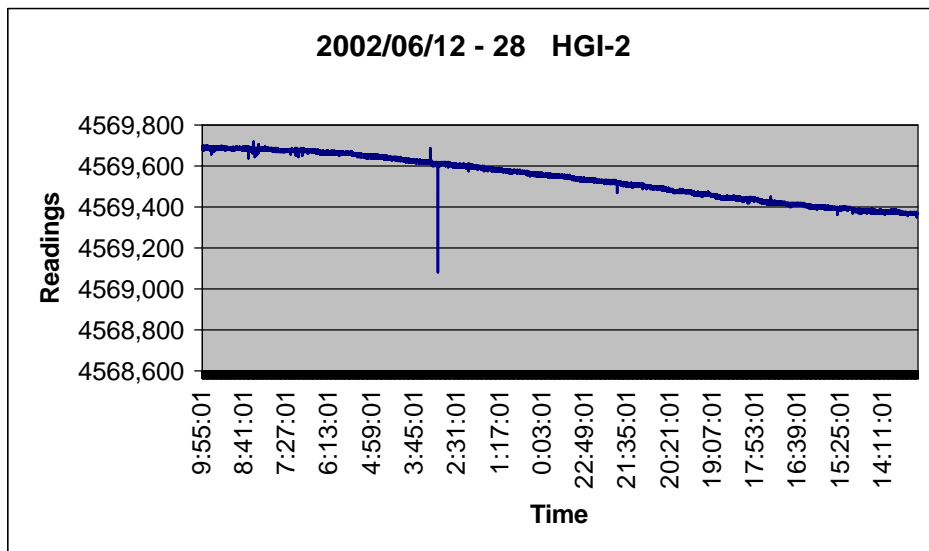


Figure 8. HGI-2 readings in the period from June 12 to 28, 2002.

On the Figure 9 signal of standard deviations for the measurements shown on the Figure 8 can be seen. If we compare them with standard deviations of HGI-1 in the same period (see Figure 4) the high correlation can be recognized. The same standard deviation signal is obtained with both gravimeters, and that is confirming that the signal is connected to site and not produced by gravimeters. Specific behavior of standard deviations signal that is in

connection with working time and activities in the building is confirming that standard deviations are under strong influence of micro seismic.

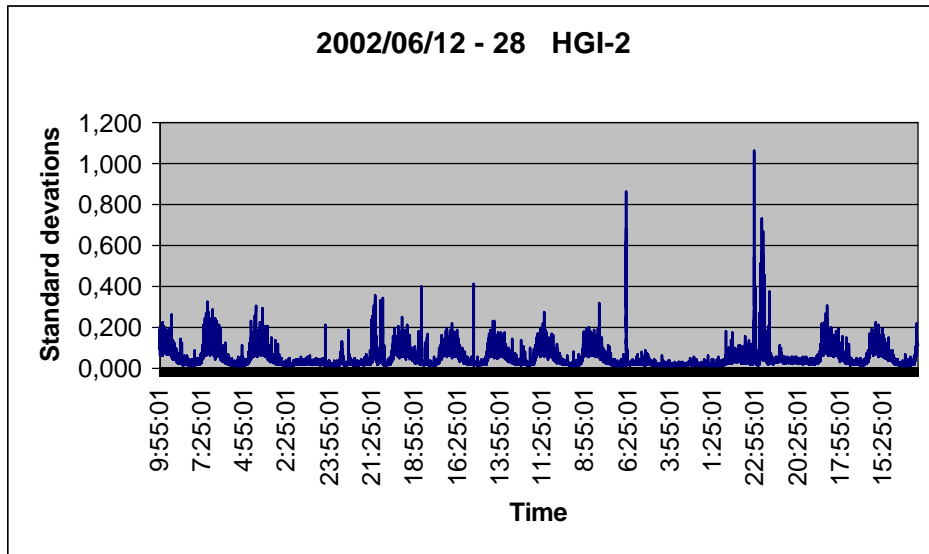


Figure 9. Standard deviations of the HGI-2 readings in the period from June 12 to 28, 2002.

Tilts for measurements in period from June 12 to 28, 2002 with HGI-2 can be seen on the Figure 10. Daily tilt periods can be clearly recognized. It has similar behavior as tilts measurements made with HGI-1 (see Fig. 5).

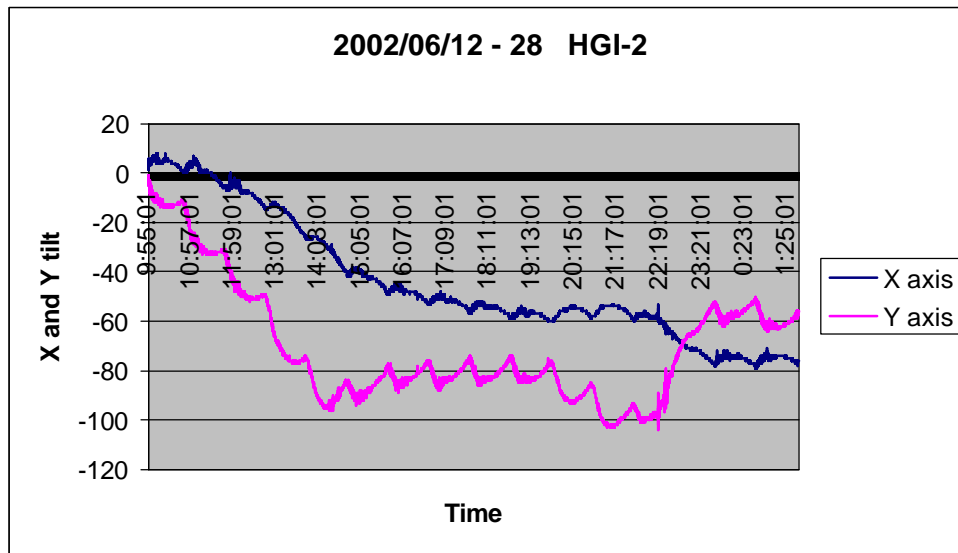


Figure 10. Tilts of X and Y axes of the HGI-2 in the period from June 12 to 28, 2002.

On the Figures 11 and 12 are presented signals for temperature and Earth tides correction from gravimeter HGI-2. That signals are behaving normally.

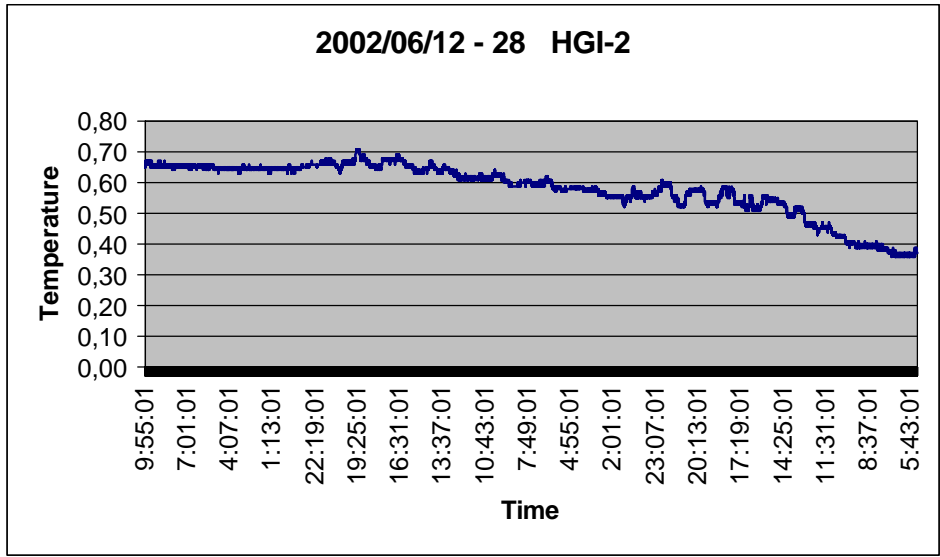


Figure 11. HGI-2 temperature in the period from June 12 to 28, 2002.

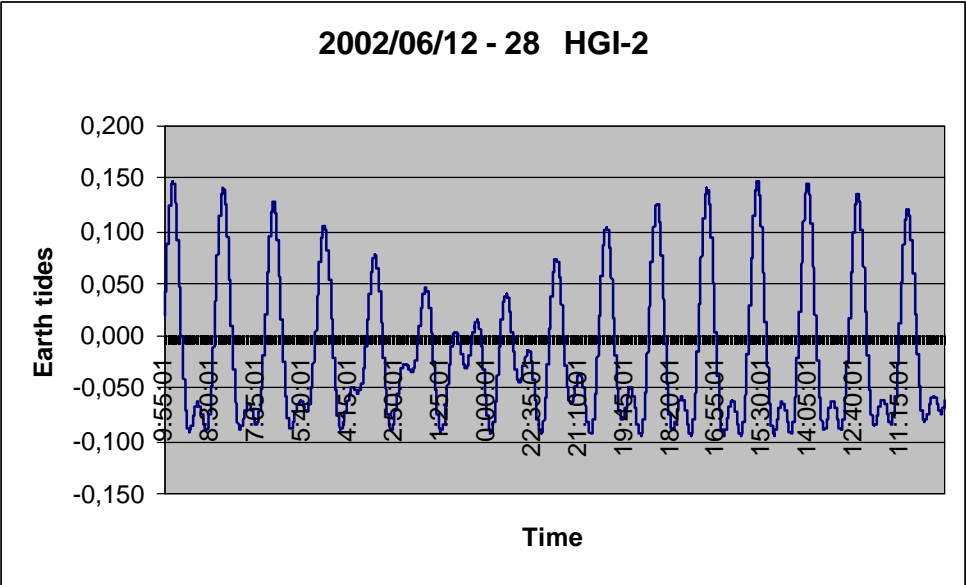


Figure 12. Earth tides corrections from HGI-2 in the period from June 12 to 28, 2002.

Simultaneous measurements with gravimeter HGI-2 does not have reading jumps. That is making confusion considering conclusion that reading jumps are connected to site. To be sure if reading jumps are connected to site or instrument, measurements on the site with very low micro seismic were done. Absolute gravimetric point outside of town is chosen. Simultaneous measurements were made with both gravimeters for seven days. Measurements of both gravimeters do not have reading jumps. That is making clear that reading jumps are connected to micro seismic behavior on the site on the 16th floor.

After that, again were made measurements on the 16th floor. Readings of HGI-1 again have jumps. That is finally confirming that reading jumps are connected to the site on the 16th floor.

4. Conclusions

Gravimeter HGI-1 has reading jumps during measurements on the 16th floor of the skyscraper. Simultaneous measurements of the other gravimeter do not have reading jumps. Analysis of the measurement signals is showing connection between reading jumps and changing of the micro seismic rate of the building. Measurements on the point with low micro seismic were done. That measurements do not have reading jumps. After that were repeated measurements in the skyscraper. Measurements of HGI-1 again have jumps. That is improving that the jumps are connected to the site on the 16th floor and dynamic behavior of the building. Jumps are connected to daily change of micro seismic rate in the skyscraper.

Scintrex CG-3M measurement sensor has one degree of freedom and can move vertically. There is very small space for horizontal movements of the sensor. In the measurements conditions with micro seismic on the 16th floor, horizontal movements are happening and during horizontal movements sensor is touching side of horizontal movements limitations and causing reading jumps. Something like that can happen if specific frequency, that is causing resonance of the sensor, influence instrument.

Gravimeter HGI-2 does not have reading jumps on the site where HGI-1 has because different characteristic of measurement sensor and different resonance frequency. In the time of these measurements gravimeter HGI-1 had static drift of 0,4 mGal/day and HGI-2 had drift of 1,0 mGal/day. Already that is showing different characteristic of sensors, and micro seismic frequencies influence measurement systems in different way.

Using measurements information from Scintrex CG-3M view in dynamic of the site can be obtained. Standard deviations are under influence of micro seismic and tilt measurements are giving information about tilting of the site.

By measurements in the high buildings and by defining vertical calibration line in high buildings, dynamical behavior of the building should be taken in consideration. Also, during long time static measurements change of micro seismic rate can cause reading jumps.

It is hard to assume that similar measurements conditions can happen during field measurements. Man-made micro seismic has specific frequencies that are rare in nature, but we cannot neglect completely that possibility.

Literature

- Brèiã I. (2002): Personal communication.
Ruymbeke, M. (2002): Personal communication.
Torge, W. (1989): Gravimetry, Walter de Gruyter.