The measurement of the gravity *g*

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04-2003

The gravity force, which allows us to define the weight of an object, keeps us at the Earth's surface and is the origin of the free fall of a body. This force is proportional with the mass: $\vec{F} = m\vec{g}$, where $\vec{g}$ is the **gravity acceleration**. The magnitude of this acceleration is the **gravity *g***, which is measured with a **gravimeter**. This is a physical quantity varying in time and space. Indeed, **g** depends, mainly, on the latitude, the mass distribution in the Earth's interior, the Earth's rotation (velocity and position of the rotation axis), and the relative positions of the Moon and the Sun, which cause the tides. The relative or absolute determination of **g** is essential in several areas of the scientific research. In **geophysics**, one measures the gravity variation to study tectonic deformations, the post-glacial rebound, the tides, the influence of the atmosphere and the hydrosphere, and the structure of the globe from the inner core to the Earth's crust. On the other hand, the analysis of the local variations of **g** presents numerous applications in **geology**. In **metrology, g** enters in the determination of standards derived from the kilogram (ampere, pressure, force) and is to play a role in the new realisation of the kilogram. Finally, **g** is indispensable to **geodesy** for the determination of the geoid and therefore of the heights (the geoid represents the average level of the seas and their prolongation under the continents).

The Observatory has acquired an international reputation in all these fields in terms of scientific knowledge as well as technical expertise. For this purpose, the Observatory has relative spring gravimeters, a relative superconducting gravimeter and an absolute gravimeter.

In a relative gravimeter, the displacement of a suspended mass is proportional to the variations of **g**. In most of the cases it concerns mobile instruments dedicated to field measurements. Besides these gravimeters, which only measure small variations of **g**, the Observatory owns an absolute gravimeter since 1996, which gives the real value of **g** with an accuracy of 10^{-9}**g** and allows a precise control of the relative gravimeters. In the absolute gravimeter, a test mass is repeatedly dropped in a vacuum chamber and its position is measured as a function of time, which provides the gravity value **g**.

The calibration factor of relative spring gravimeters often suffers from time variations and their measurements present a strong time drift too. Therefore, the Observatory installed a superconducting gravimeter in 1995 at the Membach station, near Eupen. In this instrument, the spring suspension is replaced by the magnetic levitation of a superconducting sphere, generated by constant currents trapped in two superconducting coils. The sphere and the coils are temperature regulated to –269°C and this provides a highly sensitive gravimeter that is stable for long periods. The superconducting gravimeter measures **g** variations with a precision a hundred times better than the spring instruments. In contrast with spring gravimeters, the superconducting gravimeter is not mobile, however. This instrument is also used in the framework of the "Global Geodynamics Project", a worldwide network of twenty superconducting gravimeters.

In Membach, the measurements of the superconducting and absolute gravimeters allow the study of long-term phenomena, such as a slow ground deformation (we observe an uplift of the station in the order of one mm per year). As high accuracy reference instrument, the absolute gravimeter also participates in several international comparisons and provides the base points of the Belgian gravimetric network, surveyed with spring gravimeters. This network numbers more than 69.000 measurement points, which form a data bank, managed by the Observatory since 1925. Considering the progress in the miniaturisation, the absolute gravimeters should gradually replace the spring gravimeters.

Finally, the Observatory houses the International Centre for Earth tides since its foundation in 1958. This centre contributes to the measurement and the interpretation of the deformations of the Earth under the influence of the tidal forces.

Figure 4 : The superconducting gravimeter GWR#C021 measures continuously the variations of the gravity in Membach with a precision of 10^{-10}**g**. There are about twenty superconducting gravimeters throughout the world.

Figure 3 : The absolute gravimeter FG5#202 determines the gravity in Membach with an accuracy of 10^{-9}**g**. As a function of the seasons, the value of **g** varies from 9,810 467 20 to 9,810 470 30 m/s², after correction of the known variable effects such as the tides. Presently there are only some thirty of these instruments in the world.

Figure 2 : The spring gravimeter Scintrex CG3M is one of the instruments the Observatory uses in the field. This instrument measures the variations of the gravity with a precision of 10^{-8} **g**.

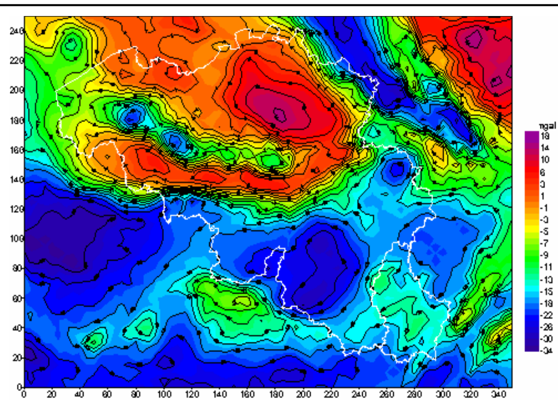

Figure 1 : Gravimetric (Bouguer) anomalies in our regions. This map reflects the variations in density of the underground rocks. It allows a visualisation of large regional geologic structures. The Brabant Massive, composed of denser rocks, is the red part in the northeast of the map. The blue part corresponds to the influence of the less dense rocks in the Ardenne and the Paris Basin. The Roer Graben, in blue in the northeast, consists in an accumulation of less dense and more recent sediments.

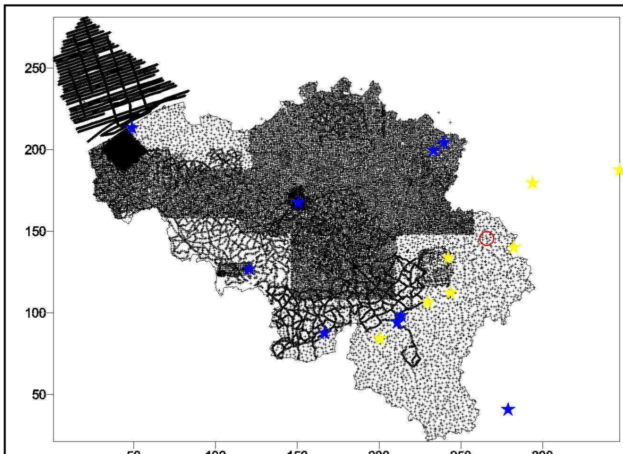

Figure 5: The Belgian gravimetric network. Each point represents one of the 69.000 measurements, made using relative spring gravimeters. The red circle shows the Membach reference station, the yellow stars give the absolute gravity measurements carried out across the Ardennes and the Roer Graben twice a year, and the blue stars represent the other absolute gravity measurements performed in Belgium.