High Resolution Dems for Near-Station Terrain Correction in Gravimetry

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Introduction
To obtain a complete Bouguer anomaly it is necessary to apply a terrain correction. This processing step is a critical concern in rugged topography, because the magnitude of the corrections may be large with respect to the anomalies of interest. The problem is particularly important in the application of gravimetry to study volcanic and seismic areas.

Normally, the terrain corrections are divided into two parts, one part being the “inner zone”, the zone relatively close to the gravity station, and the other part being the correction for more distant terrain. The latter correction is normally performed using computer routines that access a digital terrain model in form of average elevation data over a regular grid. The corrections for the “inner zone” are generally done manually through the classical template procedures (Hammer, 1939).

In the last years it was recognized how the use of automatic procedure to calculate also the inner zone (see e.g., Cogbill, 1990) leads to greater overall accuracy of the total terrain correction at each station due to the possibility to extend this zone to several kilometres from the station. An efficient technique was developed by Loddo and Schiavone (2004).

As recognized by some authors (Leaman, 1998), the greatest effects in the gravity field come from terrain near the station, which is usually not resolved by most terrain models in use. Thus, the accuracy of the anomalies is limited by the ability to estimate the near-station topography. Traditionally, this terrain effect has been estimated visually in the field. Such corrections are inaccurate since they depend on the experience of the observer and are totally qualitative.

In the present study we consider the technological developments needed to improve gravity surveying so that the gravity related data can be truly repeatable, quantitative and accurate. The developments include Global Positioning Systems (GPS) surveying and reflectorless Laser Scanners. While GPS technology is, nowadays, of widespread use in station positioning, the Laser Scanner was never considered before in gravimetric prospecting.

We present some tests carried out in the Vulcano island where the 360° near-station topography was automatically digitized with high resolution by using a Laser Scanner. A comparison was made among the correction obtained by the Laser Scanner topography and those resulting from 1:25000 and 1:10000 DEMs.

Laser Scanner Survey Test
The laser scanning technique is a new method to digitize objects and parts of territories; it is based on measuring distances by electromagnetic waves. The main fields of application are engineering, architecture and archaeology. We have few examples of studies in the field of earth sciences (e.g. Hunter et al., 2003).

The instrument sends a laser beam that hits the object and partly returns to the scanner sensor. The distance between the object surface and the scanner is computed by measuring the time of flight of the beam. This task, repeated thousands of time per second along different directions, allows to survey in real time and with millimetre precision a point cloud, from which a 3D model is obtained.

The instrument used is a Leica HDS3000; it can hit 2000 points per second with a maximum error of 6 mm on the single point position as far as 100 m.
Figure 1 shows an example of point cloud obtained at the base of the Lentia complex. In order to georeference the clouds, two tie points per cloud, surveyed by GPS antennas in differential mode were used.

Figure 2 shows the four stations used as test. The stations are located in different topographic environments. From the clouds of points DEMs with 1 m resolution were extracted up to 100 m of radius from the stations. The topographic effects resulting from the DEMs obtained by the Laser Scanner, and the digitized 1:10000 and 1:25000 maps were computed using triangular prisms (Loddo and Schiavone, 2004).

The differences in mGal between the Laser Scanner terrain correction and those resulting from the maps are shown, for the single stations, in Table 1. Differences generally greater than 0.1 mGal were obtained. These values exceed the desired level of accuracy required by the study.

Considering that the topography around the stations is not extreme, the result indicate that high resolution DEMs are generally necessary to obtain accurate anomalies.
Figure 2. Gravimetric stations considered for the terrain correction and the surrounding topography.

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Table 1. Differences in mGal between terrain correction using Laser scanner (TcLS) and DEMs from 1:10000 (Tc10000) and 1:25000 (Tc25000) maps.

References