Refraction Coefficient Determination and Modelling over the Territory of the Kingdom of Saudi Arabia

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SUMMARY

Precise levelling plays an essential role in establishing a National Vertical Reference System (NVRS). The high accuracy of precise levelling networks ensures the required accuracy for the lower order networks that are directly used for many applications related to geodesy and surveying. It is affected by many factors; one of them is vertical refraction. Extensive research shows that the influence of vertical refraction on the line of sight during geodetic activities and particularly precise levelling depends on the topography roughness along the levelling line and the air temperature. The refraction effect could reach up to 1-2 mm (with an accuracy estimate of 0.2-0.6 mm) on a measured height difference per setup and thus it could increase the final value of the loop miss-closures. The software incorporated in the present-day levelling instruments could provide a refraction correction based on a standard atmospheric model for air pressure, temperature and humidity. However, in most cases the standard model is insufficient considering that precise levelling is carried out in various atmospheric conditions and/or roughed topography. On the other hand, if precise temperature observations obtained during levelling are available, the refraction effect could be modelled and used for correcting the acquired measurements. Consequently, this would result in an accuracy improvement of the precise levelling networks.

The aim of this paper is to present the results from the Refraction Coefficient Determination for Precise Levelling Observation project related to the establishment of a new National Vertical Reference Frame for the Kingdom of Saudi Arabia (KSA). The refraction is modelled via the temperature triplets collected during the precise levelling taking into account the topography roughness along the line of sight by employing the so-called equivalent height. On the account of this method of modelling as well as the amount of data (more than 1 200 000 records), a specific software for data processing was developed. As a result, refraction coefficients (RCs) per levelling section were obtained. For assessing the relevant accuracy statistical analysis and correlation analysis were used. In addition, comparison with results based on Kukkamaki's classical formula for refraction was also made. As project deliverables, several different RC values were produced: one common RC value for the territory of the KSA; two RC values related to the existing normal and inverse atmosphere, and two RC values for different height regions in the KSA. Furthermore, the results were visualised using 2D and 3D (GIS-based) modelling. The RC models were validated with respect to the relevant levelling line and loop misclosures; the latter had dropped significantly as compared to computed misclosures without taking into account the effects of refraction. At the end of this paper, some recommendations for application of the derived RC models are presented.