INSTITUTE OF NAVIGATION AND SATELLITE GEODESY
INSTITUTE OF COMPUTATIONAL MATHEMATICS
GRAZ UNIVERSITY OF TECHNOLOGY

The New Austrian Geoid Solution

R. Pail, N. Kühtreiber, B. Wiesenhofer, B. Hofmann-Wellenhof, G. Of, O. Steinbach, N. Höggerl, D. Ruess, C. Ullrich

Introduction

In the frame of the project "The Austrian Geoid 2007" (GEOnAUT), a new Austrian geoid model has been computed as a combined solution of local terrestrial gravity field observations and global gravity field information based on data from the satellite gravity mission GRACE. The terrestrial data are mainly sensitive to medium to high wavelengths. The incorporation of the global gravity field model, representing the long-wavelength information, results in a stabilization of the solution and a reduction of systematic effects such as biases and tilts.

In addition to methodological developments of the standard technique of Least Squares Collocation (LSC), several alternative methods for the optimum combination of different (global and local) data types, such as tailored series expansion (based on spherical harmonic base functions), multi-resolution analysis using spherical wavelets, fast multipoles techniques, and algebraic approximation methods have been investigated. For the final geoid solution the LSC technique has been applied.

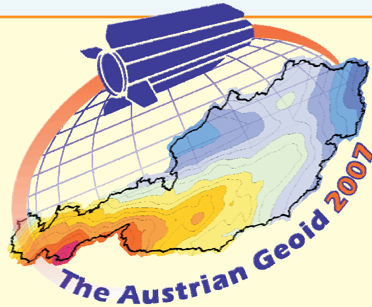

Figure 1 shows the architectural design and main data flow of GEOnAUT.

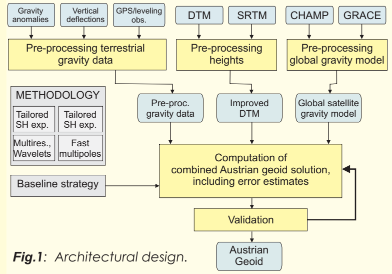

Fig.1: *Architectural design.*

Input Data

Terrestrial Data

The data bases have been thoroughly validated, and new measurements of deflections of the vertical in the South-East of Austria have been performed. Fig. 2 shows the distribution of the finally used local data:

- gravity anomalies (black; 14001 stations, approx. 4 x 4 km average distance
- deflections of the vertical (red; 672 stations)
- GPS/levelling observations (green; 161 stations).

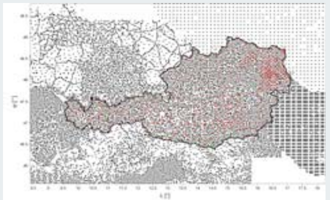

Fig.2: *Terrestrial data: gravity anomalies (black), deflections of the vertical (red), GPS/levelling observations (green).*

Global Gravity Model

As global gravity field information, the GRACE satellite-only model EIGEN-GL04S complete to degee/order 70 has been used.

Digital Terrain Model

A new digital terrain model (DTM) with a resolution of 44 x 49 m has been assembled as a combination of highly accurate regional DTMs of Austria and Switzerland, complemented by data of the Shuttle Radar Topography Mission (SRTM) in the neighbouring countries. Since SRTM reflects surface heights, a correction using Corine Land Cover (CLC90) data had to be applied.

Fig. 3 shows the deviations of the orthometric height information assigned to the gravity field stations from the DTMs, demonstrating the substantial improvement of the newly generated height data base compared to the height model formerly used.

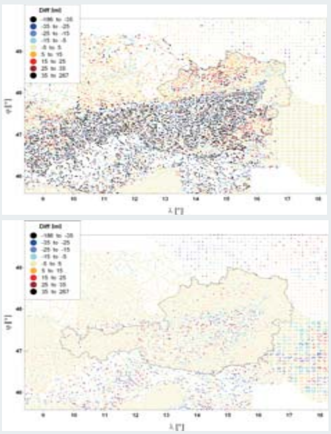

Fig.3: *Accuracy of former (top) and new (bottom) DTM.*

Geoid Computation

The final geoid solution was computed using the remove-restore technique. The basic idea is to remove the long-wavelength gravity field effect represented by the global gravity field model EIGEN-GL04S, and the high-frequency signals, which are mainly related to topography, by a topographic-isostatic reduction (Airy-Heiskanen model with a standard density of 2670 kg/m^3). After reduction all quantities refer to the co-geoid.

The reduced gravity anomalies have been used to derive an empirical covariance function and to adapt the parameters of the analytical Tscherning-Rapp covariance function model.

$$C(\Delta g_P, \Delta g_Q) = A \sum_{n=N+1}^{\infty} \frac{n-1}{(n-2)(n+B)} s^{n+2} P_n(\cos\psi)$$

Fig. 4 shows the empirical covariance function (blue dots), as well as the adapted local Tscherning-Rapp model (red solid line). The variance of the residual gravity anomaly field is 385 mGal^2, the correlation length is about 42.6 km. The adjusted parameters of the local Tscherning-Rapp model are:
$A = 332.45$ mGal^2, $B = 24$, $s = 0.99874$, $N = 70$.

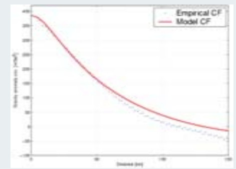

Fig.4: *Empirical and model covariance*

The New Austrian Geoid

In the frame of the geoid processing, a key aspect is the optimum relative weighting of the input data, especially concerning the GPS/levelling observations. This weighting has been performed by analysis of the residuals after application of the LSC. This information has then been used as noise covariance model in a second processing step.

Fig. 5 shows the final geoid after performing the restore step consistently. It has been thoroughly validated internally and externally by the Federal Office of Metrology and Surveying (BEV).

Fig. 6 displays the corresponding error estimates. The accuracy of this new solution can be estimated to be of the order of 2 to 3 cm, with a significant degradation in the border regions due to the insufficient input data distribution (cf. Fig. 2). This error estimate is originally based on the formal errors of the LSC procedure, but has been re-scaled using the standard deviation of the residuals at selected GPS/levelling control points, and thus can be considered as a realistic estimate for the total error.

Fig. 7 shows the improvements of the new solution with respect to the currently official BEV geoid model, which is a purely astro-geodetic solution dating from 1987. This gain in accuracy is mainly due to the substantially improved quality of the terrestrial input data and the DTM, the inclusion of a GRACE global gravity field model, as well as several methodological developments performed in the frame of this project.

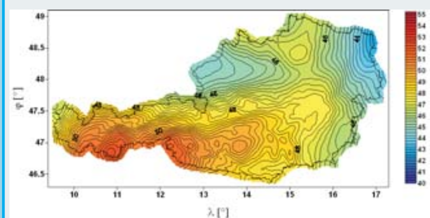

Fig.5: *The new Austrian Geoid [m].*

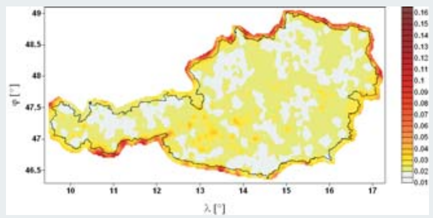

Fig.6: *Error estimates of the new Austrian Geoid [m].*

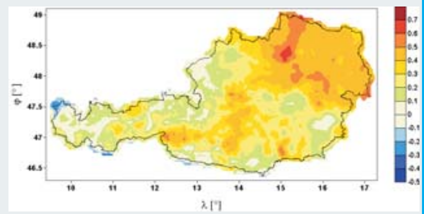

Fig.7: *Differences between the new Austrian Geoid and the official BEV geoid [m].*

Acknowledgements

This work was performed in the frame of the project "The Austrian Geoid 2007" of the Austrian Space Application Programme (ASAP) funded by the Austrian Research Promotion Agency.