Development of the Czech National Geodetic Control 2001 - 2002

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1. Densification of EUREF in the Czech Republic, Geodynamic Network

Main principes of the densification were described in (KOSTELECKÝ et al., 2001). As was described early, in the Czech Republic the ETRF89 was realized in 1991 - 1994 and implemented in 1995, (KOSTELECKÝ, DUŠÁTKO, eds., 1998). It is represented by 174 sites of the national GPS reference network DOPNUL. Since 1995 this national reference frame has been densified in two parallel ways.

The first densification has been carried out by the Land Survey Office. It is called "selective maintenance" and is based on the national GPS reference network DOPNUL. After the work is finished the total number of newly determined GPS points should be 3,500 and the final coverage will be 1 point/24 km sq. All these points are identical with the triangulation points but they are equipped with a new monumentation and a special protection against damage. Until the end of 2001 year 1,410 points were determined. Besides ETRF89 coordinates their coordinates are available in both the official national user system S-JTSK and an improved user system S-JTSK/95. In Fig. 1 the coordinate differences are displayed with respect to the "zero realization" of the S-JTSK/95. This "zero realization" is the result of the transformation of the military system S42/83 into the ETRF89, see (KOSTELECKÝ, DUŠÁTKO, eds., 1998). The standard deviation in horizontal position is 3.9 cm, little bit worse than in the last year. The differences between the new realization of S-JTSK/95 and S-JTSK are represented in Fig. 2. In this case the horizontal standard deviation is 12.1 cm. Local systematic distortions of the user system S-JTSK are also evident from Fig. 2.

The second GPS based densification has been carried out since 1995 by the regional cadastral offices (departments of cadastral mapping). The project should be finished till the end of 2002. The total number of the new points should amount to over 30,000. At present preliminary ETRF89 geocentric coordinates tied to the national GPS reference network DOPNUL are being determined along with classical plane coordinates in the national user system S-JTSK. These coordinates are determined by transformation using local transformation formulas.

After the whole work is accomplished a new stepwise adjustment "by regions" is supposed to get final ETRF coordinates. A software for the adjustment of the large geodetic networks has been developed in the RIGTC for that purpose in 2000 (KOSTELECKÝ, 2000). Common adjustment of the 1841 points, measured by GPS fast static technology in the South Bohemia region were provided. This subnetwork was connected to 10 points of DOPNUL site (see part 1). Inner accuracy of the horizontal position characterized by the r.m.s. errors is about 1.4 cm and 1.2 cm for the up components.

The Czech Geodynamic Network, maintained by Land Survey Office, Prague, was densified by new point No. 35 in the Krkonoše mountains region. In the neigbourhood of this point the geodynamical profile was measured by very precise levelling – see Fig. 3.

2. UELN 2000 Related Activities

In 2001 the relevelling in the 3rd order Czech National Levelling Network (CNLN) was ongoing by the measurement of 715 km levelling lines. Besides, 180 km of levelling lines in the Special Levelling Network (SLN) Praha, and 295 km of levelling lines in the SLN Ostrava were observed – see also Fig.3. At the end of 2001 the CNLN included 82,597 levelling bench marks connected by 1,305 levelling lines of total length of 24,825 km.

The connection of the Czech and Slovak levelling networks was realized in September 2001

3. Permanent GPS Observations

Since November 1999 the Ashtech Z18 has been run at the IGS station GOPE providing the data from both NAVSTAR and GLONASS global satellite navigation systems along with meteorological data. At present the following data files are being provided on a routine basis:

– 30 sec NAVSTAR and GLONASS daily and hourly data files regularly transferred to the IGS/EUREF data centers in Graz and in Frankfurt/Main,
– 5 sec NAVSTAR 5 minute data files stored at the observatory server and used for DGPS experiments,
– 1 sec 15 minute data files in support of IGS LEO Pilot Project.

The station GOPE has been involved in IGS, EUREF and LEO projects and also in projects oriented to the GPS ground based meteorology (e.g. COST716). The new permanent station at the University of Technology in Brno was established. Station is occupied by Trimble 4770 instrument, the same methodology of the observation and data preprocessing will be implemented as at GOPE. The station

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starts in June 2001, since September was implemented in the EPN network.

Two "pseudo-permanent" stations were established by Institute of Rock Structure and Mechanics of the Academy of Science of the CR. These stations are located in Sudeten – first at "Snezka" mount, the other at "Biskupska Kupa" mount. Both stations are occupied by Ashtech Z-18 GPS instrument and there are observing in permanent mode, but the data are collected in the operational computer only. The connection by modem and mobile telephone is in the preparation, to will be possible to obtain hourly data sets in real time.

4. EUREF Local Analysis Center GOP

The Geodetic observatory Pecny analysis center (GOP AC) was established in the cooperation of Research Institute of Geodesy, Topography and Cartography and Department of Advanced Geodesy (Czech Technical University in Prague) in January 1997. Until now, already more than 5 years of the continuous GPS analysis was performed. Actually, the GOP network consists of 32 stations.

Apart from the weekly GOP solutions contributing to the EUREF coordinate combination, from 2001 the GOP participate on the Tropospheric Parameter Estimation special EPN project. Additional delivery of hourly zenith total delays (ZTDs) to the central EPN archive are thus performed.

In 2002, using the total time-span of all the GOP analyses within the EUREF, an unique long-time combination was performed. Additionally, by a simple re-constraining the weekly and daily normal equations, we extracted the ZTDs for the last 5 years backwards and thus enabled the first insight into the potential GPS contribution for the climatology studies (global warming monitoring). The results are presented in the special poster at the meeting.

Concerning our extensive work within the near real-time (NRT) GPS analyses, we achieved fine results in 2001 for the routine monitoring of the troposphere as well as for the NRT precise orbit determination.

The first was done within the COST-716 European project ("Exploitation of the ground based GPS for climate and numerical weather prediction applications") and especially its NRT demonstration campaign in 2001 (http://www.knmi.nl/samenw/ cost716/). These hourly estimated ZTDs are already satisfactory for the meteorological community and they are assimilated into the numerical weather models (NWM) and the weather forecasting procedures during interesting periods. The latency of our product is about 1 hour after the last measurement, the internal accuracy of GPS NRT results with respect to the post-processed solution is in most cases well bellow 6 mm of ZTDs. The first independent comparison with 'reduced' profiles of radiosonde observations are between 1.0-1.8 mm of the precipitable water vapor (approx. 6-11 mm of ZTDs) depending on the profiles completness, distance of radiosondes from the GPS and many other significant factors. Although the negative impacts of GPS ZTD assimilation to NWM haven't been observed yet, the significant contribution for the potential full operational implementation is still under the development. Another special poster in this meeting is devoted to our ZTD NRT results during 2001.

Although the global NRT solution for the GPS orbit determination was iniciated in GOP already in late 2000, our pilot routine stage was officially adopted in the autumn 2001. The solution is based on 6 hours GPS data pre-analysis followed by the stacking procedures for the final three day orbit determination. The GOP orbit product is now available in 3 hour update, with the maximal latency of 2,5 hours, and follows the standards of IGS ultra-rapid orbits. The accuracy of orbits are about 12 cm (median) for the fitted arcs and 20-25 cm for the first 6 hours predicted arcs. The ZTDs estimated hourly from this global GOP NRT solution are of very high quality and in case of the European sites reaching the better consistency with e.g. EUREF combined post-processed ZTD solution than our current COST-716 ZTDs' results based on fixed IGS ultra-rapid orbits. Some significant bias between these solutions should be further studied. The results are available in the special poster describing our global NRT solution.

Last, but not least, the GOP data center (DC) (ftp://pecny.asu.cas.cz/LDC), supplying GOP AC for the NRT processing, is ready to serve to other users for any NRT analysis as well. Until May 2002, the DC mostly mirrored the anonymous sources for hourly RINEX files (more than 100 GPS sites over the world!) as well as many useful products, services or information important in real-time. The DC contents is actualized from minutes up to hours dependent on the necessity. From May 2002, the GOP data center accepts a prior data flow directly from the operational centers and would test the potential for generating the daily RINEX files purely based on respective hourly files.

5. Progress in Modelling the Detailed Quasigeoid for the Central Europe

A precise detailed quasigeoid for GPS heighting has been developed since 1996, (ŠIMEK, 1996). In 2001 year the data on the territory of Central Europe from different sources were collected and interpolated to the 30" x 30" grids. The attention has been paid to the construction of a purely gravimetric quasigeoid based on the combination of a global geopotential model and terrestrial gravity data. A geoid computed from the geopotential model EGM96 (360,360) served as a high degree reference spheroid and the detailed quasigeoid topography was modelled by the Stokes integration, Molodensky corrections were added to obtain correct solution – see NOVÁK et al., 2002. This model, was adjusted by EUVN GPS/levelling points. Final result is named "Quasigeoid VUGTK 2002" – see Fig. 4 – and is directed to GPS heighting.

Older quasigeoid model for the Czech Republic "CR 2000" – see (KOSTELECKÝ et al., 2001), was compared by 532 GPS/levelling points determined within the systematic ETRF densification described in paragraph 1. The r.m.s. error of the height component of these points is estimated to be 1.5 - 2 cm. The differences between the new quasigeoid model and GPS/levelling results for these points are illustrated in

Fig. 5. The standard deviation is 3.4 cm. Thus, the accuracy of GPS heighting in the Czech Republic is at present estimated to be about 3 cm or better over the most part of the territory.

The “CR 2000" model was also further checked by a special precise GPS/levelling profile of 80 km length across the biggest gradient of the quasigeoidal surface. The standard deviation is 1.5 cm, see *(Kostelecký et al., 2002)*.

6. Gravimetry

Gravimetric earth tides have been continuously recorded by the tidal gravimeter Askania Gs15 No. 228 with the digital feedback and since the second half of 2000 the upgraded gravimeter LaCoste and Romberg No. 137G with the new digital feedback has been employed. The same gravimeter was used for detailed measurements of the vertical gradient field around the absolute gravity point and for precise relative calibration gravity measurements.

The new absolute gravimeter of the Research Institute of Geodesy, Topography and Cartography FG5 No. 215 was installed at GO Pecný in August 2001. Since this time the absolute gravity at this station is observed in approximately two weeks intervals. Results of this measurements are correlated with various physical phenomena (eartquakes, variation of ground water, etc.).

Six secular gravity points were monumented by Land Survey Office at surrounding of Pecný observatory. Field absolute gravity measurements was performed at two new absolute gravity points PlzeÅ and Kvilda by BEW Wien. Czech gravimetric network was connected by relative measurements to absolute gravity points Bratislava (Slovakia), Keisereiche (Austria), Ksiaz (Poland) and to the three new Czech absolute points Jeseník, Svitavy and Jihlava.

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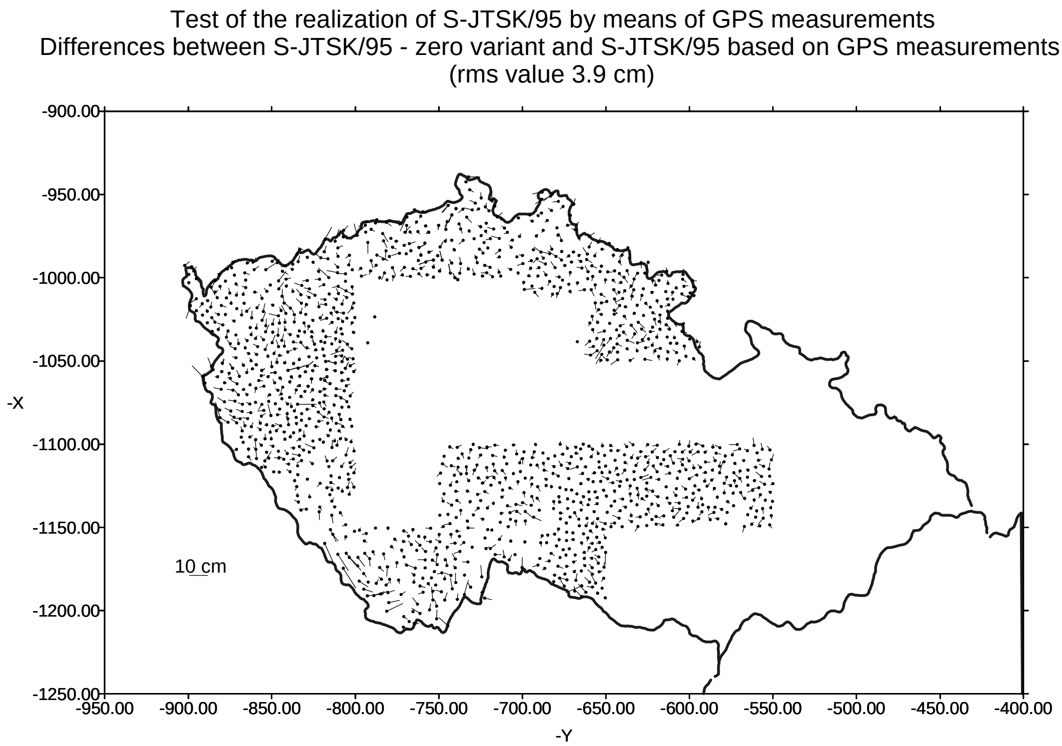

Figure 1

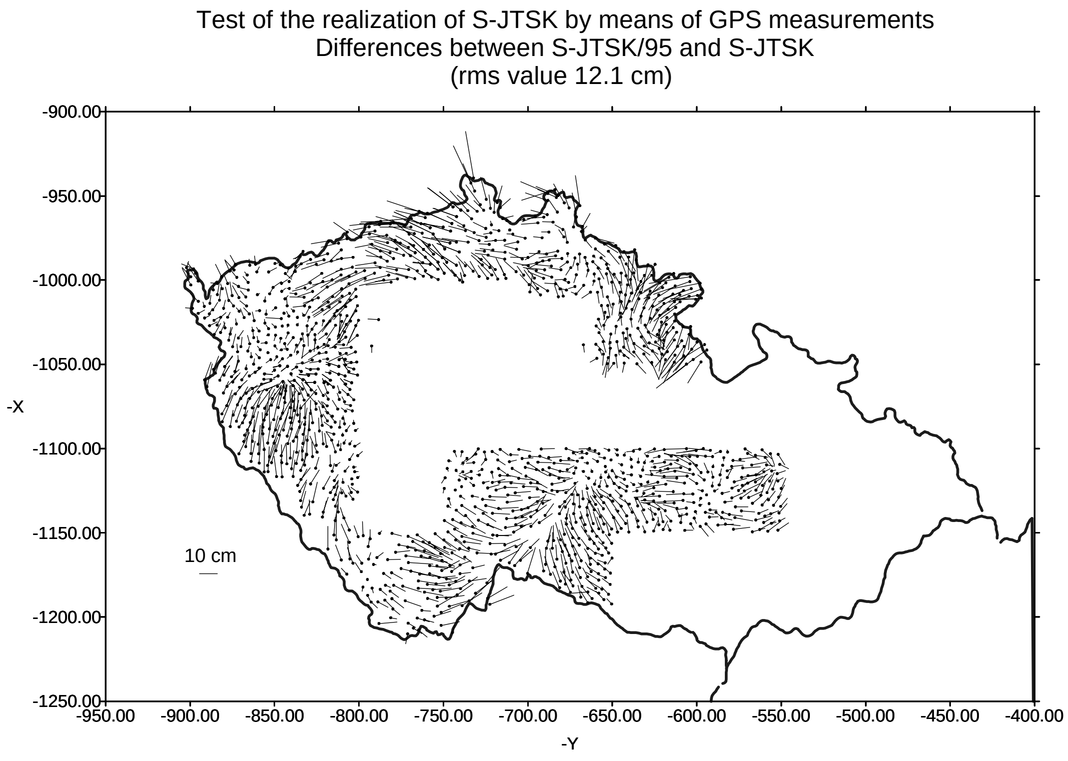

Figure 2

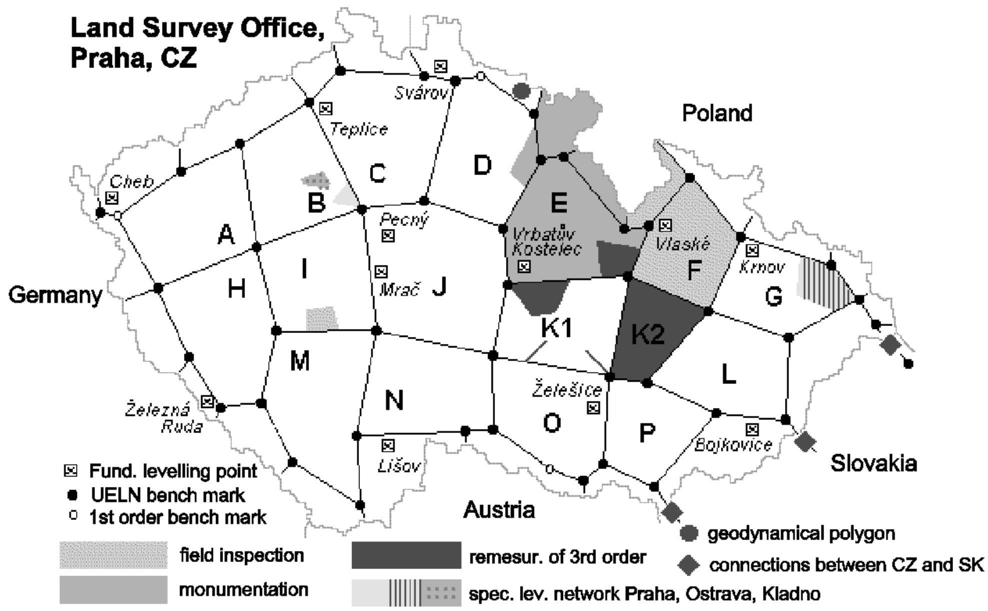

Figure 3

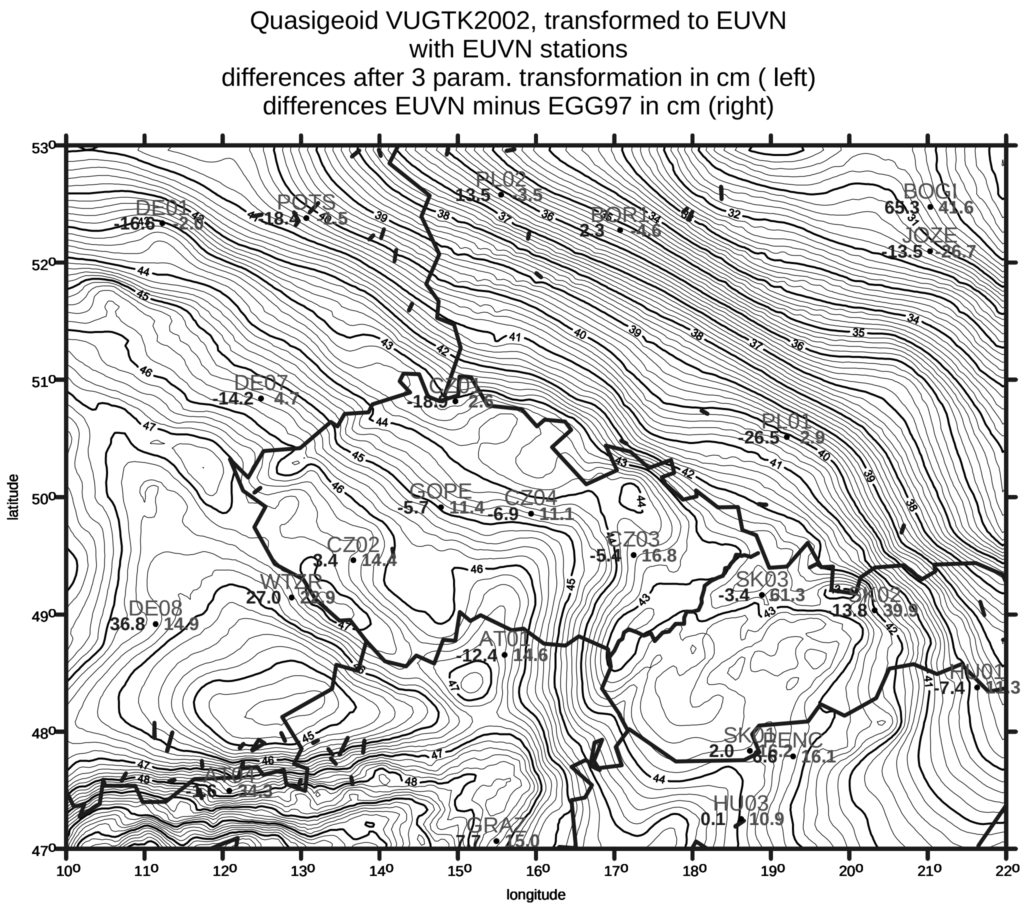

Figure 4

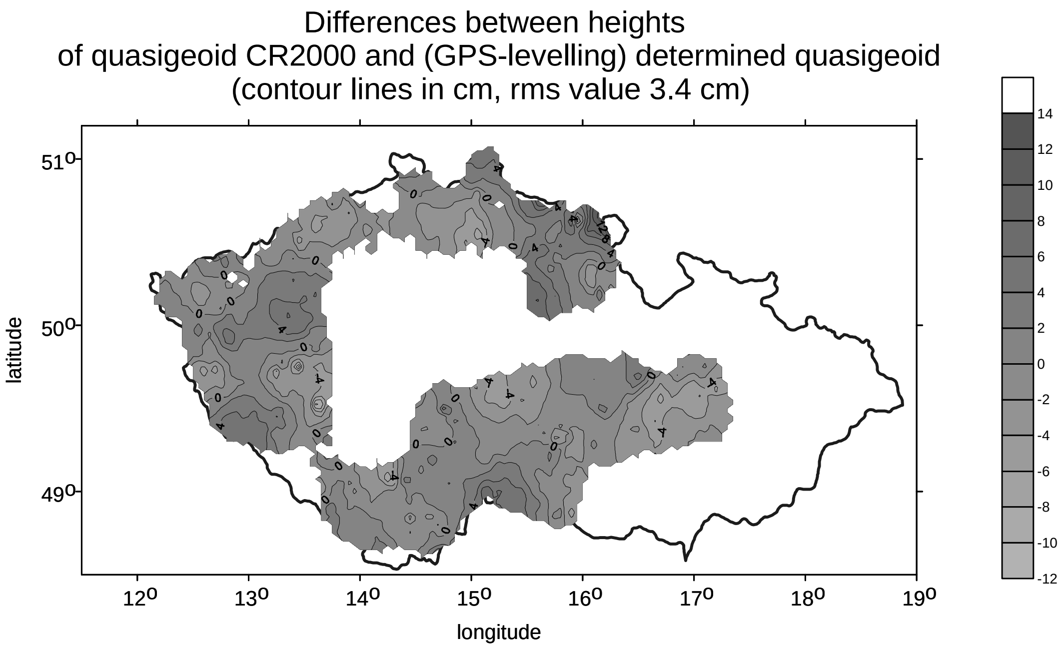
Differences between heights
of quasigeoid CR2000 and (GPS-levelling) determined quasigeoid
(contour lines in cm, rms value 3.4 cm)
51o
50o
49o
latitude
12o
13o
14o
15o
16o
17o
18o
19o
longitude
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12

Figure 5