# EUREF 13: National Report of Austria

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## 1. Positioning

The BEV (Federal Office of Metrology and Surveying) and the OLG/ISR (Observatory Lustbühel Graz/ Institute of Space Research, Austrian Academy of Sciences) have been working together in the field of satellite geodesy for many years now. The main activities of the cooperation are focused on the OLG data centre and the processing of 4 international permanent networks nowadays.

### 1.1 OLG Data Center

OLG RDC is the regional data centre for EUREF hosting all daily and hourly RINEX files. Additionally there are about 400 stations in public space, including about 100 non-IGS and non-EPN stations. Private partners for special projects of OLG LAC add about 70 permanent stations. In total about 700 stations are included/available. With the MGEX project a start was made to host also RINEX3 and high rate files.

### 1.2 Permanent Networks

Five networks of permanent GNSS stations are monitored in post-processing mode by the BEV and the Austrian Academy of Sciences. EUREF (sub-network of the EPN, 80 stations) and AMON (Eastern Alpine Region, including APOS stations, 85 stations), were designed to realize the reference system ETRS89 whereas CERGOP (Central European Geodynamics, 80 stations) and MON (Plate Boundaries in the Eastern Mediterranean, 65 stations) focus on geokinematics. The new network GREECE (Fig. 1) was established at the beginning of 2013 to investigate the boundary zone with its quick changes of velocities. It differs from the previous Greek network because it provides a regional model of the ionosphere, more reference sites and new sites not available until 2011. All networks are processed on a weekly basis according to the EPN guidelines by the OLG group.

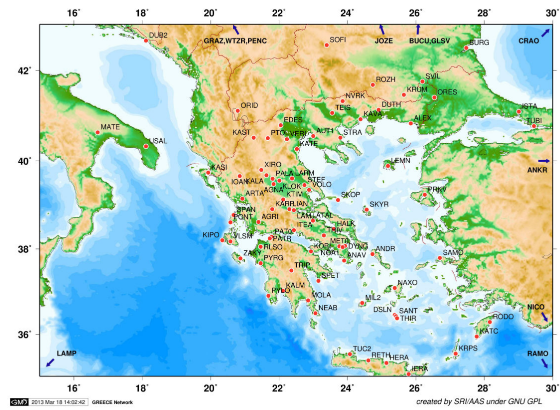

Fig. 1: Map of the network GREECE 2013

### 1.3 AMON

Reprocessing has started for AMON by using IGS05 reprocessed products and IGS08 coordinates, velocities and phase calibration values. Presently the year 2006 is finished and the year 2005 has been started. The reprocessed part was included in the AMON time series 2000-2013 because the Up component and the Up velocities provided some improvements. The horizontal velocities, which didn't change too much, are shown in Fig. 2.

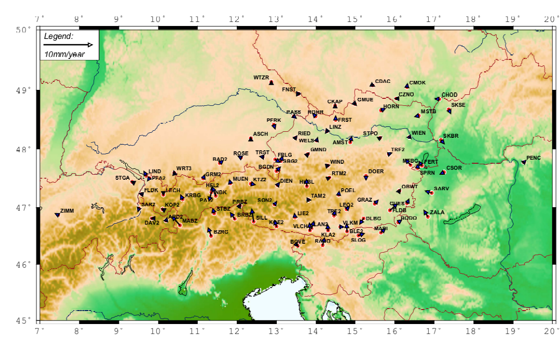

Fig. 2: Map of the network AMON with horizontal velocities of the time series 2000-2013

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## 2. Multipath Mitigation

Within the frame of the FP7 Galileo project DISAP (Displacement Synthetic Aperture Antenna) a testbed for GNSS multipath environment was established on the roof of the Forschungszentrum Graz (FZG), see Fig. 3. In addition to existing objects like e.g. a metal box, a copper plate with variable inclination angle $i$ to affect different satellite elevations with multipath, was installed as an artificial reflector. Different GNSS antenna types were tested. Here a linear polarized antenna by Antcom with a ground plane is used to record data with an IFEN SX-NSR single-frequency software receiver.

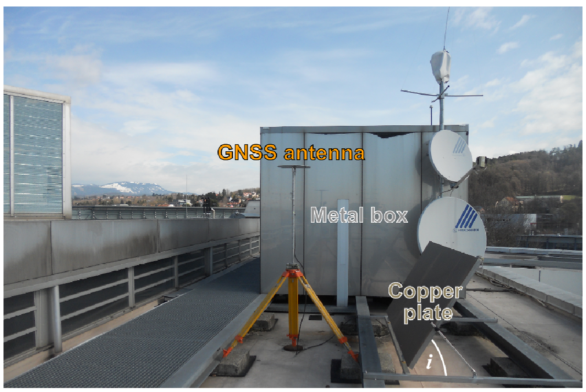


Fig. 3: Photo of the testbed at the roof of the FZG building in Graz, Schmiedlstrasse 6, taken in North-Eastern direction

Fig. 4 shows how a sky plot with the carrier-to-noise density is plotted with respect to azimuth and elevation of all visible GPS satellites for a given day. We can see fluctuations in the Southern sector for satellites with a low elevation, which can be a result caused by multipath effects due to the metal box. Here, reflections from the artificial reflector were eliminated by using the ground plane.

For satellite G05 a time series analysis is shown as an example in Fig. 5. In the upper subplot code minus carrier observations reduced by a simple model of the Earth's ionosphere are plotted, in the middle subplot the carrier-to-noise density $C/N_0$ is shown and in the lower subplot the elevation of the satellite is visualized. The highlighted areas were calculated by a simulation of the GPS satellite constellation and the environment of the testbed, respectively, black for signal obstruction, copper for reflection by the artificial reflector, grey for reflection by the metal box and light blue for expecting signals without any obstruction and reflection. If we focus on the grey time window from approximately hour 16.5 to 17, we will see increasing code minus carrier values of some ten meters as well as signal fading in the $C/N_0$ plot. Both features indicate multipath because of the metal box.

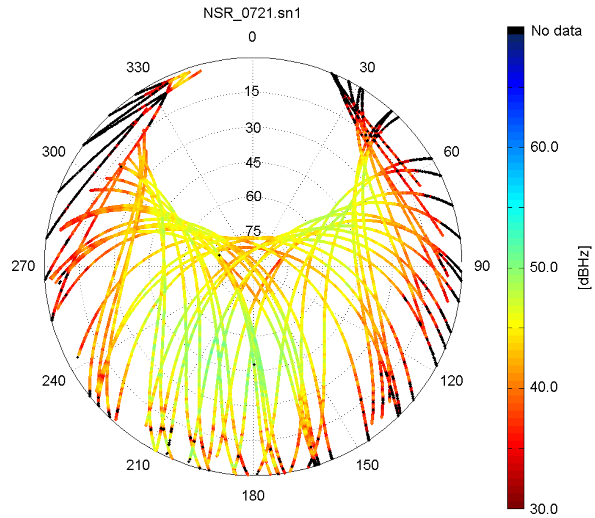


Fig. 4: Carrier-to-noise density for DOY 072

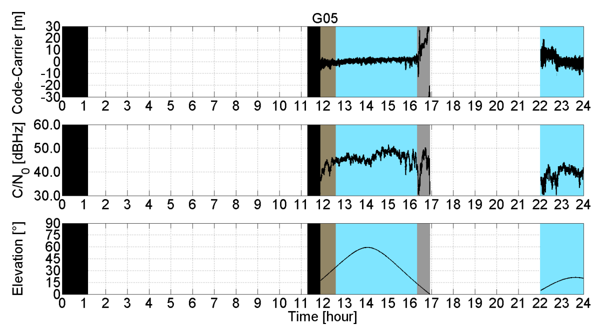


Fig. 5: Time series analysis for satellite G05 for DOY 072

Without ground plane tests have shown overall fluctuations of the carrier-to-noise density. Indeed reflections from the copper plate and the ground cannot be distinguished. This will be investigated in the next phase by refining the testbed. Furthermore, satellites of other GNSS, e.g. GLONASS and Galileo will be added. At the end of the project the innovative DISAP antenna from IFEN will be installed on the roof of the FZG to prove the multipath mitigating effect of the DISAP antenna within the testbed.

## 3. ETRS89 - Coordinates of Control Points

Based on the national realization of ETRS89 in Austria (EUREF campaign 2002 approved at the Symposium in Toledo) the realization of all national control points is in progress. The coordinates for the points of 1st to 5th order are determined by the adjustment of observation data (GNSS-baselines, trigonometric observation and distance measurements) and for the 6th order by the Austrian Real Time Positioning System APOS [Imrek and Höggerl, 2011]. At the moment the ETRS89-coordinates of 76.500 control points are available for the customers. Thus, the BEV provides local and regional transformation parameter.

Besides of the 3-dimensional Cartesian coordinates, ellipsoidal coordinates (GRS80), UTM-coordinates, accuracy of coordinates, velocities (not yet) and Geoid undulations (Bessel and GRS80) are provided. Within the next 3 years the ETRS89 - coordinates of another 72.000 point should be added.

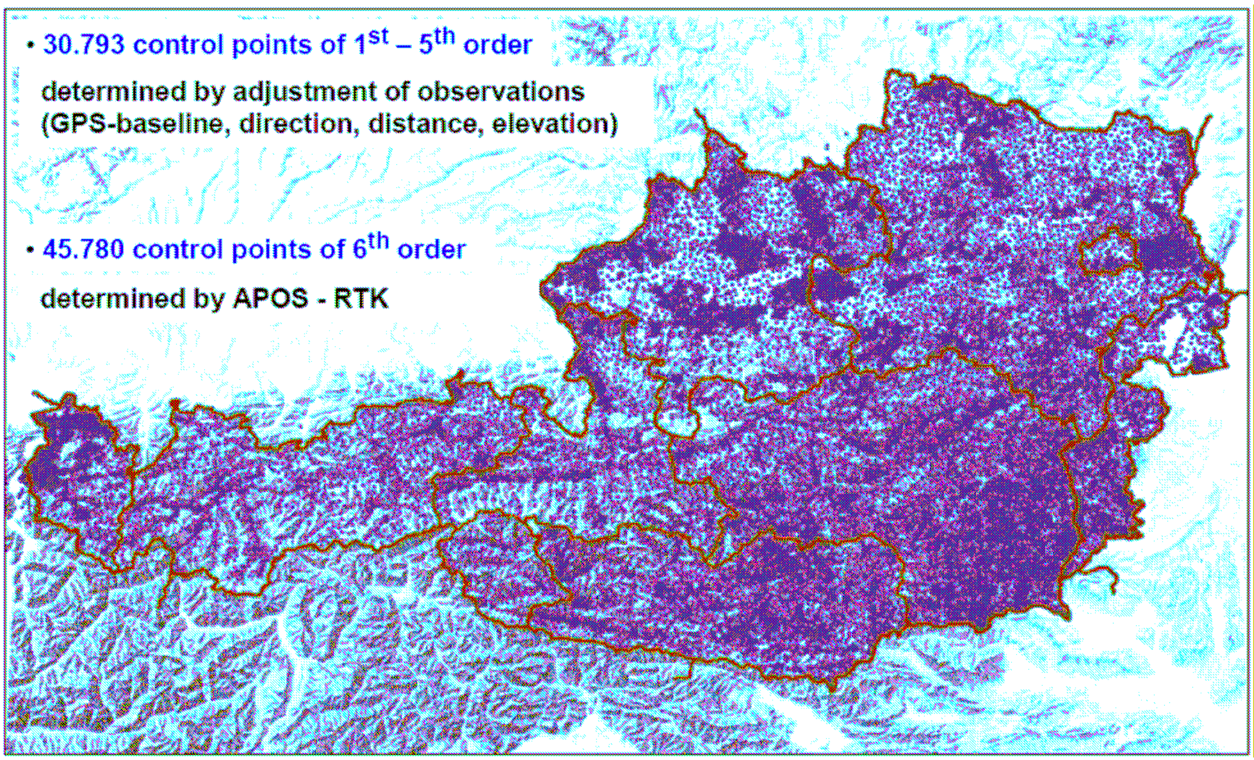


Fig. 6: Control points with ETRS89-coordinates

## 4. APOS - Austrian Positioning Service

### 4.1 APOS Production System

The APOS reference station network uses raw data from about 70 stations operated by national and international associate partners (see Fig. 7). The upgrading of the central software from Trimble® VRS³net to the new Trimble® Pivot Platform is scheduled for the middle of 2013. By the end of 2012 national associate APOS partner KELAG (Kärntner Elektrizitäts-Aktiengesell-schaft) had replaced all SW/HW infrastructures by Leica components for GNSS network-RTK and data streaming. The BEV/APOS-team has allocated a GIS-sub-grid for the Carinthian area which was implemented successfully in KELAG's Leica GNSS Spider-SW.

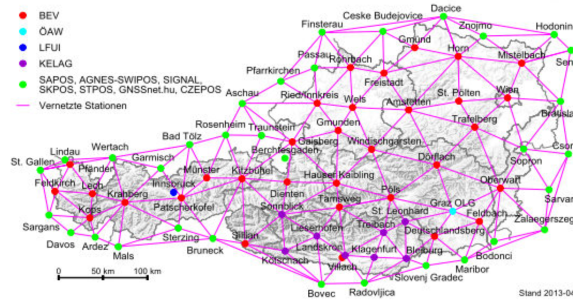


Fig. 7: APOS - reference station network (status 2013-04)

#### 4.2 APOS Production System - Monitoring Aspects

As previously described in the National Report of Austria 2012 the height offsets shown by RTK monitoring measurements at the station INBK still remain stable/ the same, whatever the station was equipped with (GNSS- or GPS-antenna/receiver combination) so far. INBK is situated in Innsbruck at a distance of approximately 10 km from the APOS station PATK (Patscherkofel) but at a much lower altitude (altitude difference: 1,634 m). A certain correlation between changes in height offset at the APOS Station INBK and such of relative humidity logged by ZAMG (Zentralanstalt für Meterologie und Geodynamik) measuring elements at INBK (i.e. university) and PATK (top) seems to be evident. According to that we chose a representative time span from 16th to 23rd of April of the ZAMG time series and compared those with our RTK monitoring time series (fig. 8). At a relative humidity level of about 30% to 60% and differences between INBK and PATK in nearly the same range height offsets even went down to zero (fig. 8 (a)). Over rainy periods offsets stated nearly 17 cm. As is generally known troposphere modelling at the rover side does include only standard parameters and therefore basically could be the reason for such deviations. However, for 2013 additional performance measurements in the region of Innsbruck and also in the Salzburg/Gaisberg area are scheduled, where the altitude differences are far smaller.

#### 4.3 APOS Production System - Commercial Aspects

Up to now about 570 external customers, respectively more than 1,360 accounts of “APOS Real Time” in all kinds of working fields have been registered. By October 2012 nearly 7,000 online hours had been reached. In 2012 “APOS Real Time” had been used by 7 % of the time via GSM and 93% via Mobile Internet. On the other hand the demand for RINEX-Data (APOS Postprocessing) decreased slightly.

In general HW/SW-companies have free access to APOS for testing and equipment demonstration but not for commercial purposes. To proof that a monthly internal evaluation took place by visualizing the companies dial-in positions with reference to certain situations visible e.g. in the national map of the BEV. Recently detached wrong rover-side account configurations resp. misuse could be cleared up.

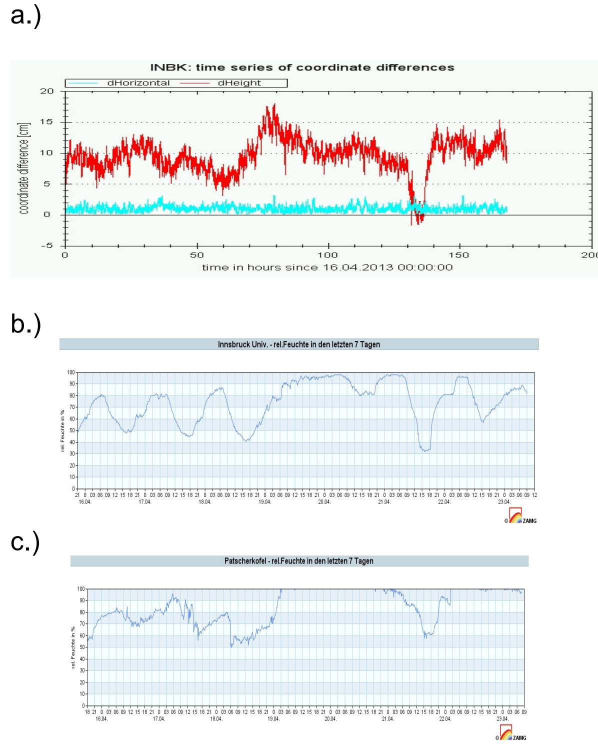


Fig. 8: Time series (16th to 23 rd of April ) of RTK-monitoring height offset (red graph (a)) and relative humidity of ZAMG sensors at INBK (b) and PATK (c)

## 5. Gravimetry

In 2012 absolute gravity measurements were continued only at the stations Obergurgl and Trafelberg (ECGN station TRFB). The discrepancies between the new results and the old values required more detailed investigations of the source. The reason was a strong drifting of the Rb-frequency normal which only occurred at the station TRFB. The drifting was verified by repeated calibrations. At TRFB the gravity results of the absolute gravimeter FG5-242 were compared to the results of the super conducting tidal Gravimeter GWR which leeks Helium (about 100 l/year). The increased Helium concentration in the ambient air influences the Rb-frequency normal, this was confirmed by a several FG5 users in Canada and Japan. Using a new GPS controlled frequency normal (system Kronos / Microg-Lacoste) outside the gravity laboratory, in which the GRW and FG5 are operating, solves this problem temporarily.

The long-term observation (more than 20 years) of the increasing gravity values in Obergurgl/Tyrol in the Central Alps of Austria was published in Cryosphere. There a valuation of deglaciation in the surrounding area gives a possible explanation for this effect (Fig. 9 and

10). A seasonal effect due to the winter snow mass is shown in figure 9.

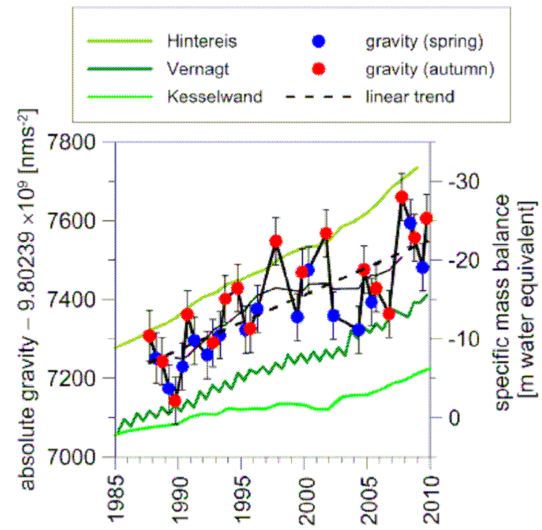


Fig. 9: Absolute gravity time series at Obergurgl (weighted means of each campaign) between 1987 and 2009. Symbols in blue refer to observations in spring; red symbols are used for autumn campaigns. A significant gravity increase can be derived for this time period. Gravity values determined in autumn tend to be higher than values determined in spring. Gravity is compared by cumulative specific mass balance observations (greenish colours) for prominent glaciers in the Oetztal Alps (Austria) (Kuhn et al., 1999; Fischer and Markl, 2009; WGMS, 2011).

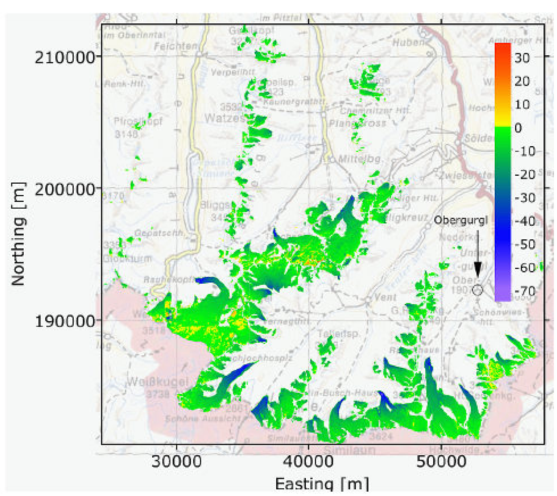


Fig. 10: Ice thickness variation (m) at the Oetztal Alps during the period between 1997 and 2006 derived from glacier inventories (Abermann et al., 2009). The small circle indicates the location of the gravity station in Obergurgl. Coordinates refer to the Gauss– Krueger coordinate system with central meridian 10°20’E (northing coordinate reduced by $5 \times 10^6$).

## 6. Precise Levelling

Due to limited capabilities only 96 km of precise levelling could be measured in 2012. The main part was measured in the eastern part of Austria continuing the program of re-measuring the connection to the EVRF Datum point Hutbigl. Nevertheless a new connection between Italy (South Tyrol – Alto Adige) from Obergurgl via the Timmelsjoch (2474m) could be realized. Furthermore cooperation with the BBT (Brenner Basistunnel BBT SE / Galleria di Base del Brennero) facilitated the acquisition of precise levellings between Volders/Innsbruck and Brenner Pass. Due to re-measurements in South Tyrol 2009-2012 the border-crossing loops Italy-Austria will be stabilize the UELN network in the Alpine region (Fig. 11).

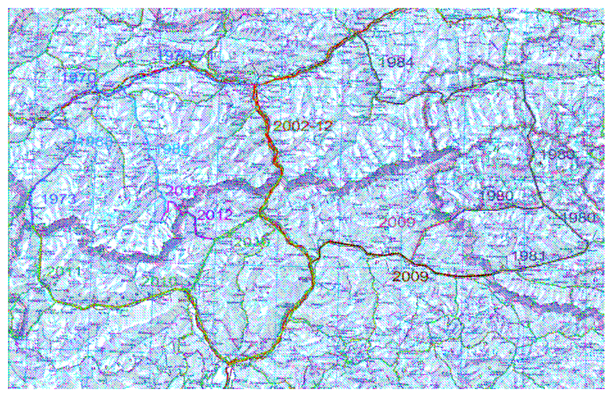


Fig. 11: Precise levelling loops between Austria (Tirol) and Italy (South Tyrol) and their datum

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