National Report of Switzerland: Geodetic activities at swisstopo presented to the EUREF2012 Symposium

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1 Geostation Zimmerwald

1.1 SLR

Zimmerwald confirmed being one of the world-wide most efficient SLR observation stations. Various improvements in the software (e.g. C++ code instead of FORTRAN for the recording part and other improvements for the controlling part) enabled a quite stable operation for the SLR tracking and also for the CCD astrometry. Due to the high measurement rate, almost the complete GLONASS constellation is tracked.

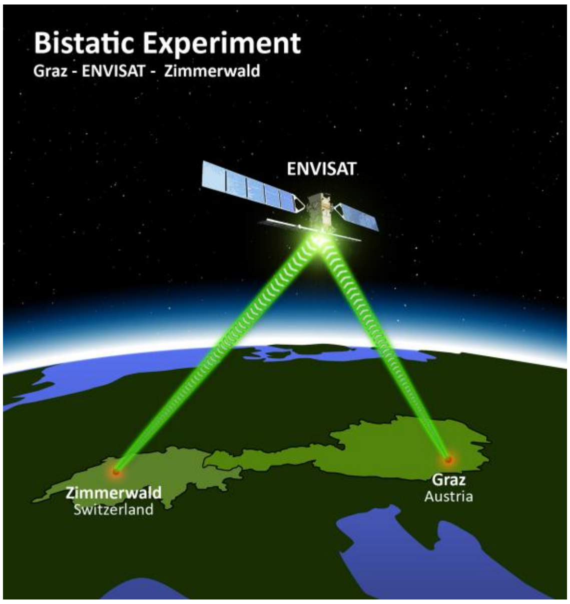

Fig. 1 Scheme of the Bistatic experiment. First successful measurements conducted on March 28, 2012.

The research groups at the Astronomical Institute of the University of Berne (AIUB) are now able to cover all steps: from the measurement to the analysis of the data for both techniques, SLR and GNSS. The validation with GNSS-derived orbits allows interesting in-depth comparisons and may thus enable model improvements. Observations to the LRO (Lunar Reconnaissance Orbiter) are standardized and part of the routine operation. The huge number of observations collected in the last week of September 2011 is worth to be mentioned: 572 passes were observed (27% more than that collected in the second best week). Furthermore, the “bistatic experiment” of Graz, Zimmerwald, and the ENVISAT satellite is a world premiere: observations from the SLR station Graz were received via reflections at the ENVISAT satellite (Fig. 1). Due to the fact that the photons collected in Zimmerwald are stemming from diffuse reflections, this method might potentially be applied to the monitoring of space debris.

1.2 GNSS

The permanent GNSS receivers ZIMM and ZIM2 were sending its data (hourly and daily) to the IGS and EUREF networks. NTRIP data of station ZIM2 are provided in real-time to the three broadcasters of the EUREF-IP activity.

Since August 22, 2011, RINEX3 data of ZIM2 are generated and uploaded to the data centers BKG (together with eight other stations in Europe) and CDDIS (as first station of the IGS network). Although the ZIM2 receiver is not yet collecting data of Galileo, this new data format is essential for the future, where a multitude of new GNSS signals will be available. A test receiver from Javad, capable to track almost all currently available GNSS signals, was mounted on the ZIMJ marker. The antenna was calibrated in Bonn (anechoic chamber) at the beginning of 2011. Unfortunately, problems with the software did not allow to provide RINEX3 files on a regular basis to the IGS pilot project M-GEX (Multi GNSS experiment) till today.

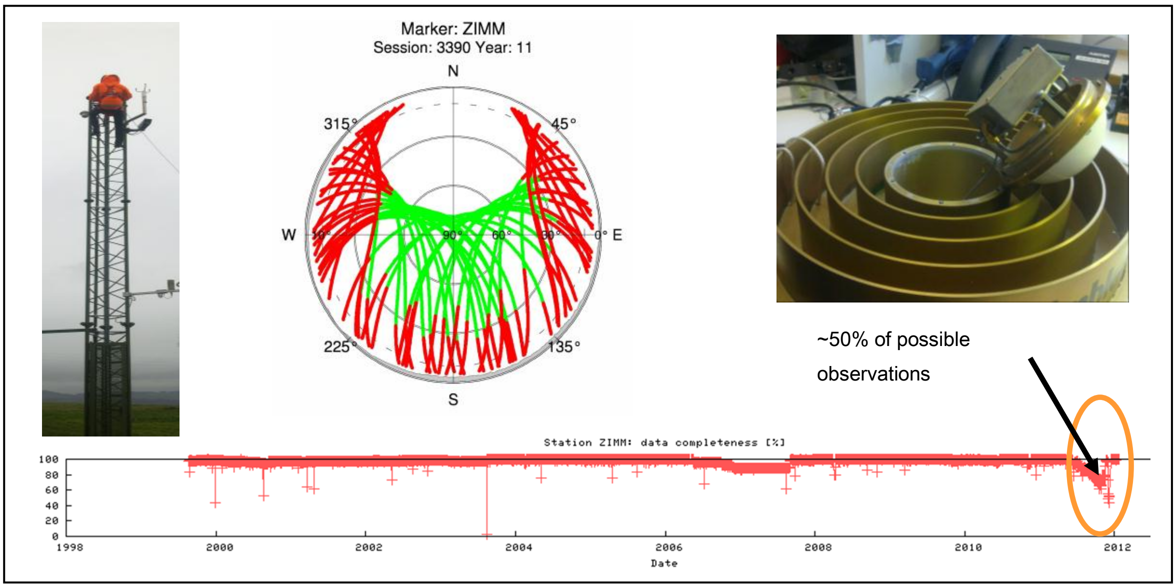

Fig. 2 Illustration of the "rescue" activity due to a malfunctioning antenna for ZIMM. In December 2011 less than 50% of possible observations were collected. The change of the pre-amplifier finally solved the problem.

A special "rescue" activity needs to be reported for ZIMM. After the long and stable operation since 1998 (the bottom diagram in Fig. 2 shows the percentage of observations collected since 1999), the antenna collected less than 50% of the possible observations (no L2 observation below 30 degrees of elevation). After several tests (the antenna was demounted for one week), the antenna pre-amplifier was replaced. By avoiding an antenna change, the long-time series of ZIMM could be extended without any discontinuity. The importance of the long-time series for reference frame maintenance was the main reason to setup in 2007 an extra station ZIM2 for collecting also GLONASS data (rather than replacing the antenna at ZIMM).

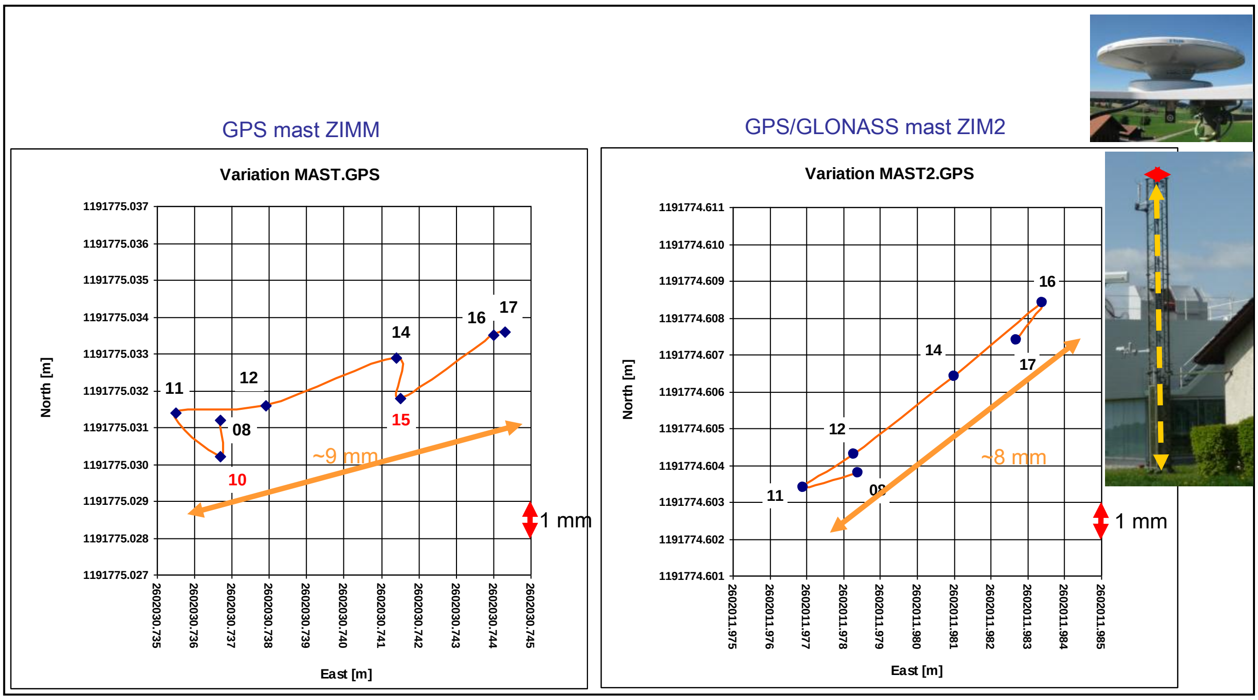

Fig. 3 Time variability of the top of the 9-meter masts ZIMM (left) and ZIM2 (right) during a hot summer day (August 22, 2011).

1.3 Local ties

As already reported in the last annual report, local tie measurements are performed in Zimmerwald regularly. From the investigations made in 2010, possible movements of the masts due to varying temperature and solar radiation were visible in the kinematic residuals of short L1-baselines. On August 22, 2011, an extreme hot summer day was chosen by intention to verify possible movements of the top of the 9-meter masts of ZIMM and ZIM2 using classical geodetic measurements. The results, achieved from local tie measurements at 21 degrees Celsius in the morning and 30 degrees Celsius in the evening, clearly show a movement of 8-9 mm for both masts (peak-to-peak in the horizontal plane according to Fig. 3) and also a small temperature-dependent extension of the mast (peak-to-peak 1.5 mm, not shown here).

2 Gravity Field and Geoid

Absolute gravimeter measurements were unfortunately not possible in 2011 (due to problems with the FG5 owned by the Federal Office of Metrology (METAS)).

Relative gravity measurements were performed on various levelling lines (altogether 3 field weeks).

The earth tide gravimeter ET-25 in Zimmerwald operated smoothly.

A special investigation concerning the geoid determination in the eastern alps was carried out together with the Swiss Federal Institute of Technology Zurich (ETHZ). Additional measurements of the deflection of the vertical and additional GPS-levelling measurements were used to refine the geoid in this high-alpine region. Finally, the results validated the geoid determination of 2004, which showed at that time differences to the geoid determination 1998 of more than 20 cm.

A personal highlight has been the appointment of Dr. Urs Marti as chair of the IAG Commission 2 (Gravity Field) for the years 2011 to 2015.

3 Permanent GNSS Network AGNES

3.1 Infrastructure

In 2011, three permanent stations were moved from their original location. Station SARG (Sargans) was moved to a new place, because the time series of this station revealed a fairly unstable underground, leading to a constant "velocity" of 3-4 mm/year in a southward direction. A new marker and a new mast were built for station ANDE (Andermatt), where annual variations of 2 cm in direction North-South were observed during the last 10 years. Double station FRI2 got an extension of the mast (from 9 to 12 meters) to be less affected by the nearby trees.

A new station concept was developed, where the complete power supply is based on 12 V and where all connections between the various equipments are centralized. With the exception of the 10 double stations, there will be no longer a PC running on the station. Generally, the design is more modular and compact compared to the computer racks used today. Unfortunately, the RINEX files generated via conversion tools from internally logged data files on the receivers show quite some differences to the presently provided RINEX files, generated directly on the station PCs. The first installations according to the new station concept are planned for the end of 2012.

3.2 Permanent Network Analysis Center (PNAC)

The characteristics of the permanent GNSS networks, analyzed by swisstopo already since more than 10 years, are shown in Table 1. The routine operation of the Permanent Network Analysis Center (PNAC) is divided into three sub-network solutions, which are generated on an hourly and an daily basis.

Table 1. Network analyses of permanent GNSS data at swisstopo (status for end of 2010).

Network solution	Stations	Processing interval	Delay
1: EUREF (EPN) sub-network	max. 49	daily observations	14-21 days
2: AGNES + sub-net EUREF + third-party sites	max 120 (41 AGNES)	daily observations	14-21 days
3: AGNES + sub-net EUREF+ third-party sites	max 117 (41 AGNES)	hourly observations	1:45 hour

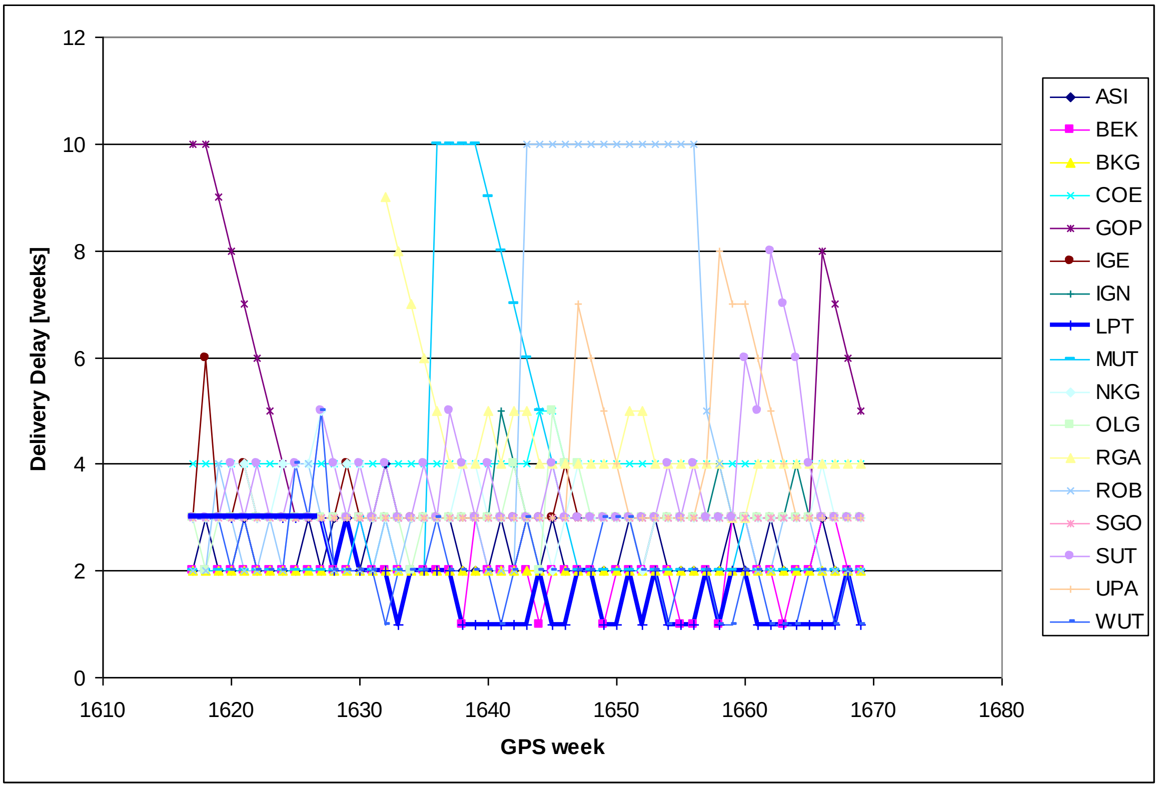

Fig. 4. EUREF delivery statistics for 2011 (LPT=swisstopo, derived from former abbreviation L+T).

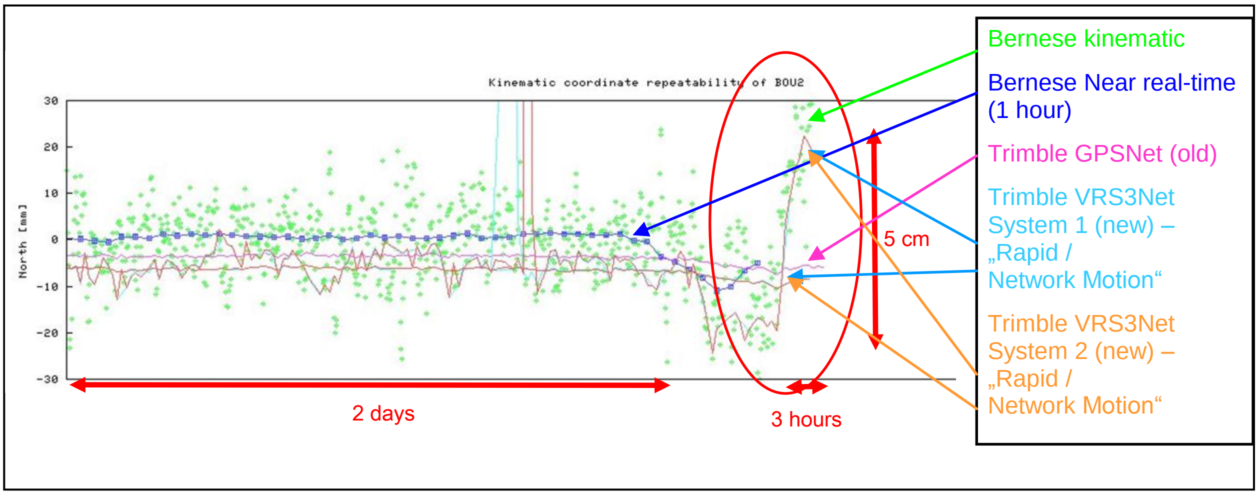

Fig. 5. Quick monitoring of station BOUR (North component) on January 24, 2012 using the Bernese Software 5.0 and old and two new redundant (almost identical) Trimble network solutions (old: GPSNET, new: VRS3NET).

All analyses are done with the Bernese Software 5.0. The use of synergies with the global analyses of the permanent network of the International GNSS Service (IGS) performed at the Astronomical Institute of the University of Bern (AIUB), which operates the Center for Orbit Determination in Europe (CODE), could be realized by several software modules which are absolutely identical at AIUB and swisstopo. Concerning the collaboration within CODE, it is worth mentioning that the IGS Bias and Calibration Workshop was held in Bern on January 18-19, 2012. This workshop gave interesting insights into the various biases of the GNSS systems and enabled, thanks to the fact that the RTCM meeting took place the days before, a very fruitful information exchange between science and industry.

The number of new analyzed sites has continuously been increased including foreign stations close to the Swiss national border (partly also delivering data in real-time for the positioning service swipos®), third-party stations, and new EPN stations.

An external network of 9 stations in the northern part of Switzerland has been completely integrated in the various processing chains.

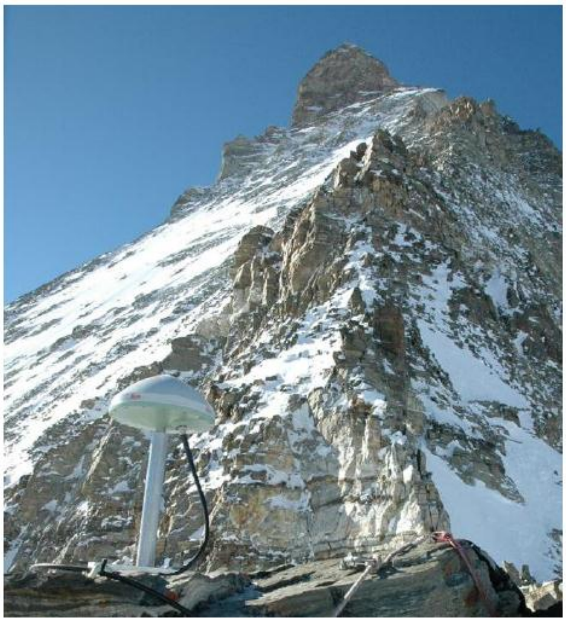

Fig. 6. Station Hörnligrat located on 3500 m (1000 m below the top of the Matterhorn).

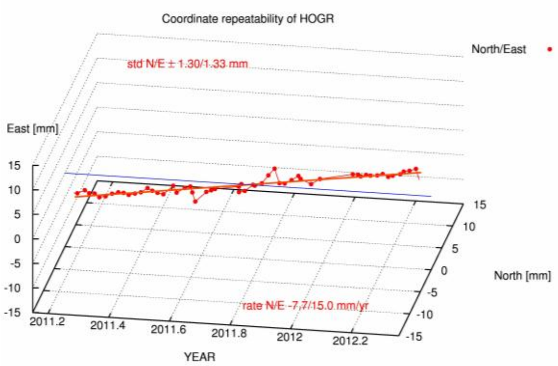

Fig. 7. 2-D time series of station Hörnligrat (HOGR) with a velocity of 18 mm/yr.

Due to the fact that older stations stopped operation, the total number of processed sites increased in the last year only very moderately.

In collaboration with the ETHZ, tectonic sites are included in the south-western part of the Alps. The most extreme station is the station Hörnligrat, very close to the Matterhorn and located on an altitude of 3500 m (Fig. 6). This particular site seems to have a significant velocity of 18 mm/yr in the horizontal direction (Fig. 7).

The main processing products are continuously derived coordinates for reference frame maintenance and zenith total delay estimates for numerical weather prediction. From solution 1 of Table 1, swisstopo contributes, as one of several European processing centers of the European Permanent Network EPN, with weekly coordinate and troposphere parameters. Solution 2 and 3 of Table 1 are used for monitoring the Swiss reference frame in near real-time and generating products used in federal surveying and for scientific applications (GNSS meteorology).

Significant changes were introduced in GPSweek 1632 (mid of April, 2011). Synchronous to the IGS, the reference frame was changed from ITRF2005 to ITRF2008 and the antenna model from I05 to I08. The GLONASS satellite antenna offsets in this new model were provided from the CODE analysis center. The impact of the new I08 antenna model is mainly dependent on the used antenna type. In case of the ZIMM antenna (Trimble choke ring), the derived coordinates differ by more than 4 mm in east direction. Various analyses at CODE showed that the model improved the consistency between GPS and GLONASS results for the coordinates as well as for the troposphere. With the changed models also the weekly processing schedule was slightly improved. As shown in Fig. 4, LPT (abbreviation used for swisstopo) usually submits the weekly EUREF products with a delay of 1-2 weeks based on GNSS orbits of CODE, which is about a week faster than before the model change.

Investigations in the direction to real-time were realized by routinely analysing the NTRIP-data stream of ZIM2 using the BNC software. Furthermore, the monitoring results of all stations used for the positioning service are displayed on the swisstopo web pages. Results using the Bernese software (near real-time and kinematic) are plotted together with results achieved with the network RTK system for coordinates and troposphere parameters. This possibility was helpful for the transition from the RTK software GPSNet to VRS3Net (see next section). An example, showing the various monitoring results for the North component for station Bourrignon during heavy snowfalls, is shown in Fig. 5. Within 3 hours, residuals of 5 cm are possible. Whereas the network mode of the RTK network software packages GPSNet and VRS3Net cannot follow the rapid changes (the Kalman filter options only allow to identify a coordinate change after several days), the monitoring mode "rapid motion" shows similar results as extracted from the Bernese processing.

4 Positioning Service swipos®

In 2011, the positioning system swipos® was running smoothly without remarkable problems. The availability of the swipos server was more than 99.8% (measured externally by a private company). The internal monitoring of the availability of stations with more than 5 visible satellites gave a value of 99.4%.

Very positive is the continuously increasing number of users and licenses sold (see Fig. 8).
Similar to the changes at the permanent stations (see above), several changes were realized. Since mid of 2011, the swipos central server infrastructure was built at the private company BEGASOFT AG. Totally, 12 virtual servers, divided into two redundant operational systems (TDE1 and TDE2 as hot stand-by according to Fig. 9) and a test system (TDE Test). The swipos clients are directed via a load balancer to the one or the other system and in case of a system crash all users are automatically redirected to the remaining system, which is designed to have enough resources to handle the total number of currently observing users. Furthermore, the RTK network software was changed from GPSNet to VRS3Net.
Beside the advantages in the coordinate monitoring (see above), the RTCM generators are dynamically assigned (the bottle-neck of a fixed number of customers vanished). With respect to the observation modelling, absolute antenna models are introduced and the virtual reference station corrections are referring to a "NULL antenna" (instead of the antenna type of the nearest reference station).

In a testing phase in September/October 2011, 30 national reference points were measured using the old and the new system. The achieved accuracies (2 sigma) were in the order of horizontally < 2cm, and vertically < 4cm, which fulfils the specification. In April 2012, the transition of all clients to the new system took place. Since mid of May 2012, all customers of the positioning service swipos® are successfully migrated to the new system.

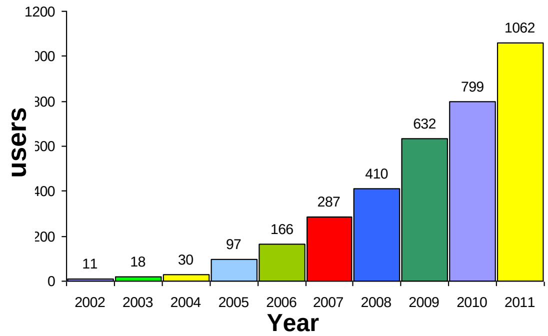

Fig. 8 Development of swipos licences.

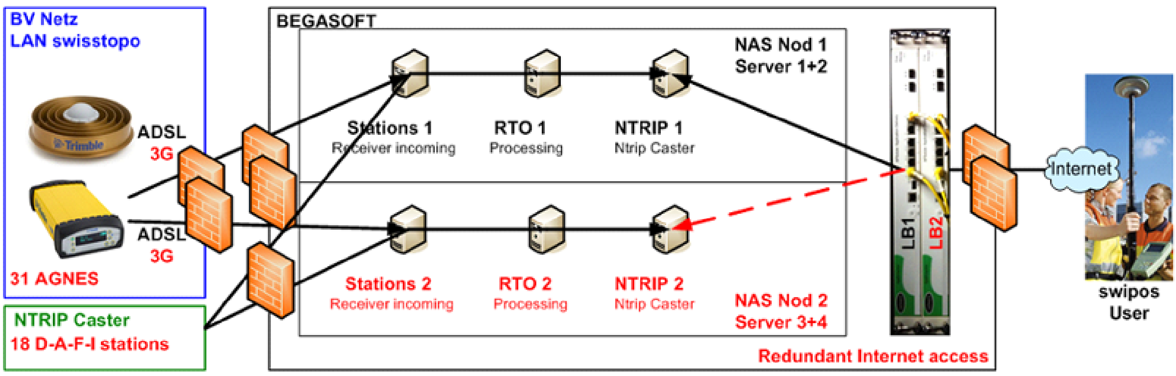

Fig. 9 Server architecture of the AGNES Network RTK control center.

5 National Reference Frames

5.1 Control points

After the successful re-measurement (April – October 2010) and analysis (Brockmann 2011a) of the Swiss Reference Network LV95, the resulting velocity information was made available in various graphical representations. The vectors and error ellipses are available in ArcGIS together with other relevant information such as the vertical velocities derived from levelling or in combination with, e.g., geological information (Fig. 10). A corresponding KML file was generated which can be displayed together with maps, ortho-photos, and geological data using the national geoportal map.geo.admin.ch (Fig. 11).

For maintaining the LV95 reference network, 34 points in the western part of Switzerland were inspected on-site according to the maintenance cycle of 6 years. Furthermore, the local ties of point St. Maria and minor revisions at two other points were realized. Next to the reference point “Brütten”, a new marker was built celebrating the 100 year anniversary of the Swiss Cadastral surveying in 2012.

5.2 Height network

100 km levelling lines (Olten - Aarburg - Sursee; Pfäffikon - Sattel - Oberarth; St. Gallen – Rorschach) were observed in 2011 including gravity measurements. Moreover, the gravity measurements were performed on the lines which were not measured in 2010. Totally, 135 km levelling lines (4 campaigns) were prepared to be measured in 2012. According to the maintenance concept, more than 350 height reference points were checked and changes were introduced in the data base of the control point data service (FPDS). In addition, 80 points with problems reported by users got revisions.

In autumn 2011, a kinematic height network adjustment in the northern part including levelling results from Germany was started with the goal to detect vertical motions in this region. Furthermore, the Italian colleagues linked the height network of the Bolzano region with levelling measurements to the Val Müstair (monastery St. Johann).

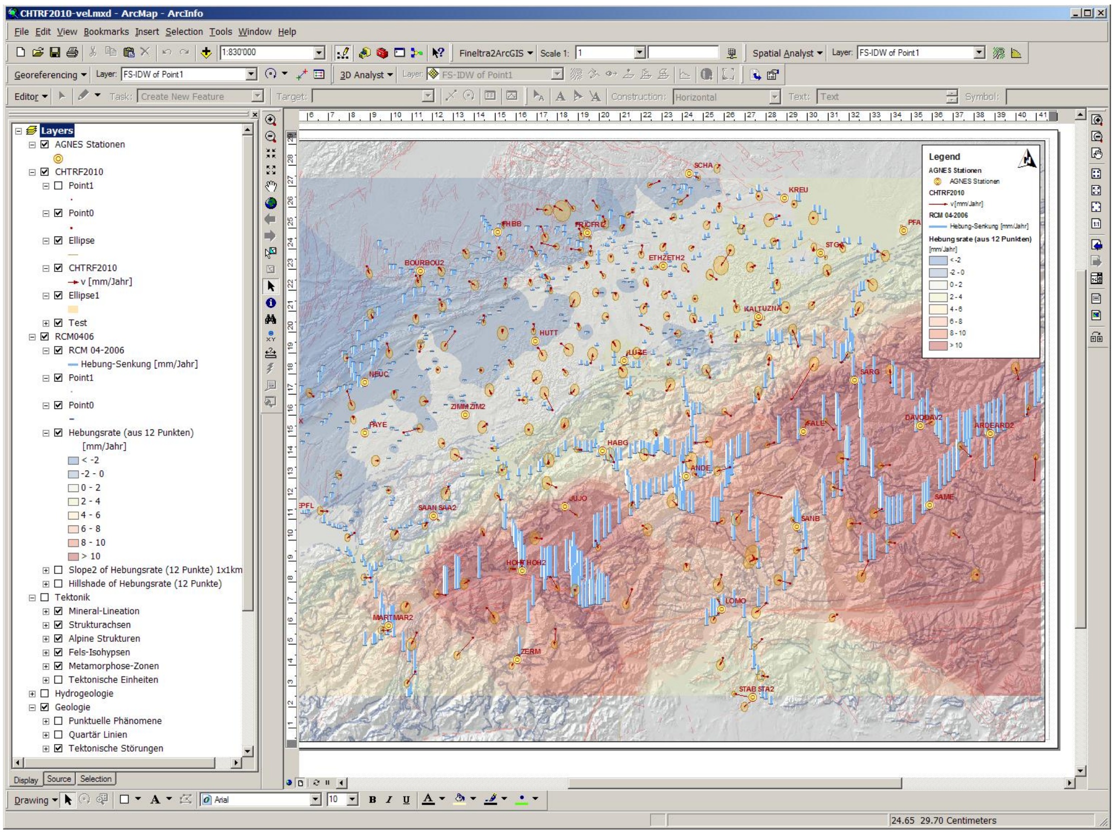

Fig. 10 CHTRF2010 velocities displayed together with the vertical velocities derived from levelling in ArcGIS.

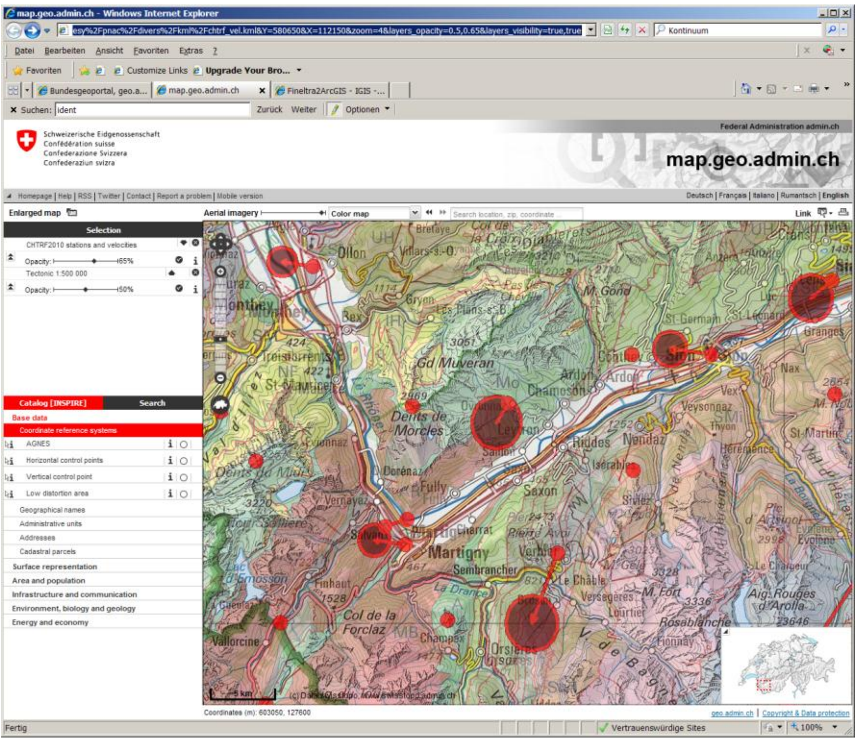

Fig. 11 CHTRF2010 velocities in the southwestern part of Switzerland displayed on map.geo.admin.ch together with geological information.

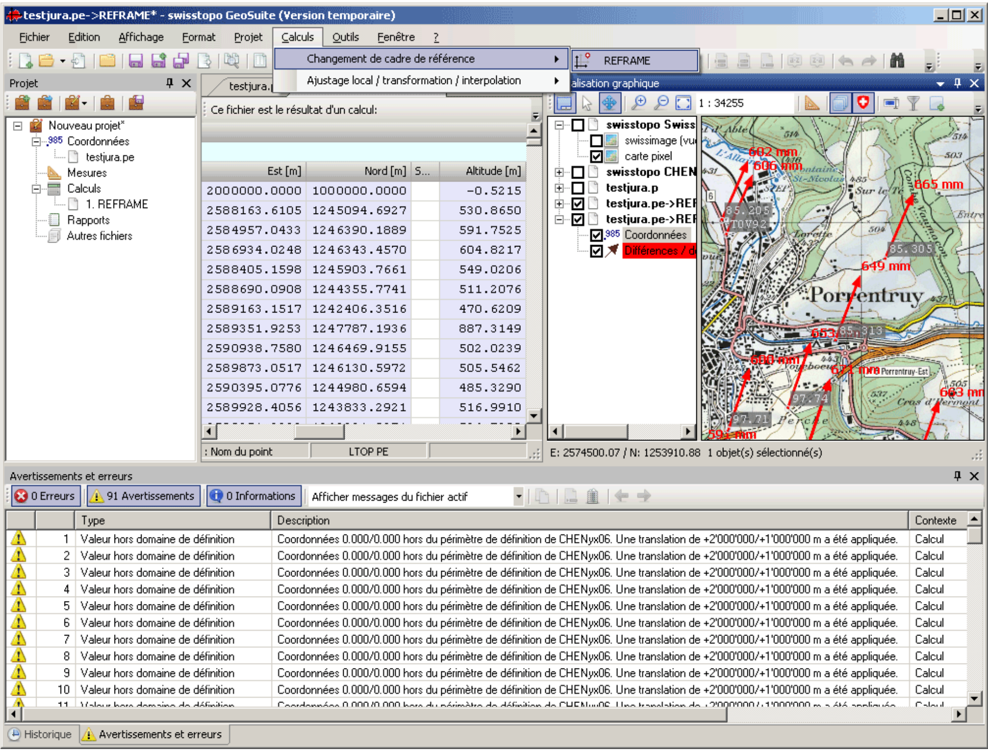

Fig. 12 GeoSuite: Program supporting users to transform coordinates from the old to the new reference frame LV95 using the transformation program REFRAME and displaying coordinate differences.

5.3 Transformation from the old to the new reference frame

The transformation data set CHENyx06, which defines the transition from the old to the new coordinate reference frame, was not modified in 2011. To assist the cantons and local authorities in their work to straighten their local networks and to detect network distortions in the old reference frame, swisstopo develops a software module, called TRANSINT, allowing to find best possible interpolations and to find suited transformation points. The module is part of the GeoSuite program, which is the basis for all other geodetic programs, such as coordinate transformations (e.g. module REFRAME according to Fig. 12) and adjustment modules (LTOP) and which has lots of visualization features. GeoSuite will be released later in 2012.

The web-based tools available for all Swiss users for transformations of various file formats up to a size of 25 Mb was moved from internal servers to Amazon Web Services (AWS).

As the second of the 26 cantons, the canton of Geneva realized in June 2011 the transition from the old reference frame LV03 to the new reference frame LV95. The work was coordinated by the "Système d'information du territoire à Genève (SITG)" and supported by swisstopo. The feedback of all partners was very positive and the advantages of the new reference frame were highly approved, especially for transnational cooperation.

Furthermore, the cadastre authorities started to designate officially the areas with low torsions all over Switzerland. In these zones, published in the national geoportal map.geo.admin.ch, cadastral work can been done more efficient in an "absolute" way (e.g using GNSS) without consideration of local surveying points.

5.4 Control Point Data Service (FPDS)

The Control Point Data Service (Fixpunkt-Datenservice FPDS) makes available all geodetic control points in a central database. On a daily basis, the data are exported via a shape file to the web-based geoportal map.geo.admin.ch. In addition, the data are exported to the INTERLIS format and furthermore automatically checked for data inconsistency via an INTERLIS check tool. Besides the routine maintenance of the points (in all three dimensions), the production of maps showing the points was finished. In 2012, new import/export interfaces based on Java will be developed in order to replace the externally, in a proprietary language developed scripts (infoGrips iG-scripts).

6 Events and further publications

In 2011, the Swiss Geodetic Commission, member of the Swiss Academy of Sciences, celebrated its 150th anniversary. swisstopo made contributions to the jubilee events as well as to the special edition of the journal *Geomatik Schweiz* 6/2011.

Further reports on geodetic activities at swisstopo are published in the Swiss National Report on the Geodetic Activities in the years 2007 to 2011 presented to the XXV General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Melbourne, Australia, June/July 2011.

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