Name of research institute or organization:

Bundesamt für Landestopografie / Swiss Federal Office of Topography (swisstopo)

Title of project:

Automated GPS Network Switzerland (AGNES)

Project leader and team:

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Dominique Andrey, Daniel Ineichen, Christian Misslin, Dr. Stefan Schaer, Dr. Urs Wild

Project description:

The permanently observing GPS (Global Positioning System) station at Jungfraujoch has been operating since autumn 1998. The station is part of the Automated GNSS Network of Switzerland (AGNES) consisting presently of 31 sites, partly equipped with GPS and GPS-GLONASS (the Russian equivalent of GPS) combined receivers and antennas. Global Navigation Satellite Systems (GNSS) is the abbreviation for all existing and future satellite navigation systems and therefore include also the planned European Satellite System Galileo. Station JUJO is equipped with a GNSS receiver since summer 2007, but due to the extreme weather conditions the GPS-only antenna was not upgraded to GPS-GLONASS, yet.
AGNES is a multipurpose network which serves as reference for surveying, real-time positioning (positioning service swipos GIS/GEO) and for scientific applications (geotectonics and GNSS-meteorology). The GPS station JUJO is mainly contributing to scientific applications.

Activities at site JUJO and at the analysis center at swisstopo
2009 can be characterized as a consolidation phase. Beside routine checks at the station no changes were made to the infrastructure of the AGNES station JUJO. The generated products, namely GNSS-meteorology and geotectonics, were continuously generated.

GNSS-Meteorology
From the hourly analysis of the GPS data zenith total delay estimates (ZTD) can be derived with a time delay of approximately 1:30 hours. These GPS-derived humidity information can be used e.g. for numerical weather prediction. The goal of several European projects, such as COST-716 (ended in 2004), TOUGH (Targeting Optimal Use of GPS Humidity; ended at January 31, 2006) and E-GVAP (EUMETNET GPS Water Vapor Programme; ended Mid 2009, and the currently running E-GVAP II project) is to operationally use these data for numerical weather predictions. Therefore, MeteoSwiss and other European meteorological institutes are deeply involved in these activities. The status is not much changed compared to the year 2008. The number of sites contributing to the actual E_GVAP II project exceeds now the magic number of 1000 sites – JUJO is the one with the highest altitude.

GPS-tomography and **a**ssimilation in **nu**merical **we**ather models (GANUWE) is a Swiss project in which improvements of the numerical weather prediction (especially precipitation) using the tomography approach of GPS-data and additional data (radio sonde, meteorological surface measurements, lidar) are developed by ETHZ (GGL) and MeteoSwiss. The project is financed by the Federal Office of the Environment (FOEN) and is supported by the data stemming from the routine swisstopo analyses. Furthermore, the swisstopo products are sent to the university of Berne (IAP) , to be part of a database, which collects all possible climate data sources in the framework of the STARTWAVE project (part of the Swiss National Fund NCCR Climate Project).

Geotectonics

The permanent analyses of the data covering several years of data result in hourly/daily/weekly coordinates which can be used to study possible movements of stations – results from more than 10 years of observations at JUJO were presented in the report 2008.

The fact that the Swiss Alps are still rising is already known since several years from the analyses of levelling data covering a time span of more than 100 years. With respect to the, as stable assumed, reference bench mark in Aarburg, the maximal relative vertical velocities reach 1.5 mm per year for areas in the Valais and Grisons.

A comparison between a vertical model computed from the levelling lines (in blue) and the GNSS-derived vertical rates (in red) are given in Fig 1. The vertical movement of the complete territory of Switzerland derived from GNSS is in average about 1.2 mm/yr (average for the midland an pre-Alps stations) compared to the "stable" European plate

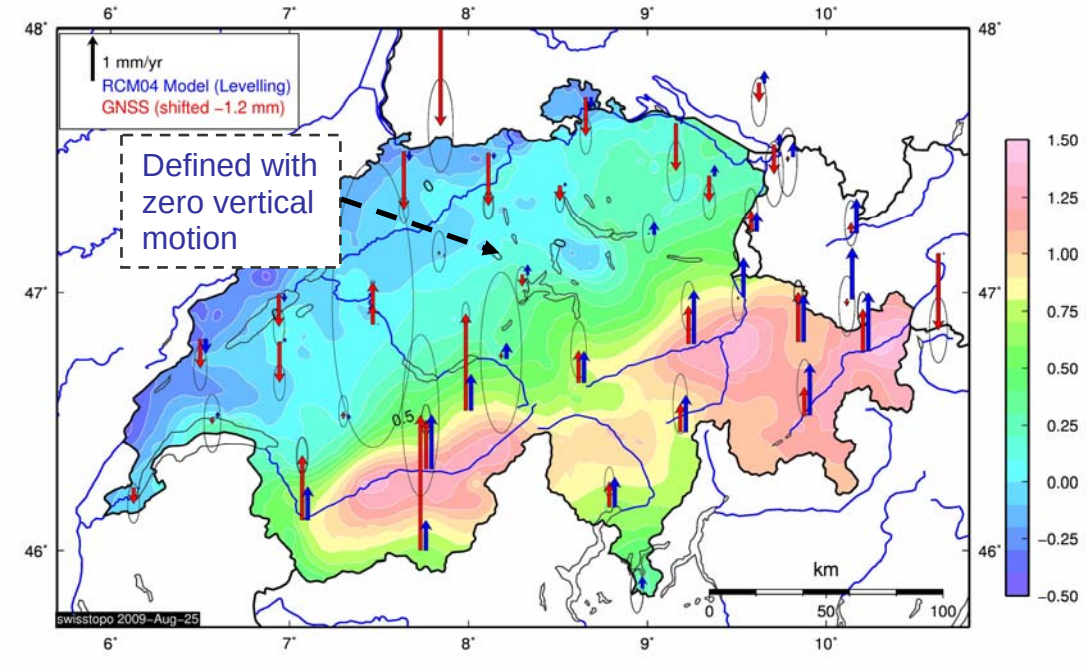

Fig. 1: Comparison of vertical velocities between GNSS and the levelling-derived model RCM04 expressed in the Swiss system (Aarburg zero vertical velocity). Red arrows indicate GNSS rates, blue arrows indicate RCM04 model values (levelling) at the AGNES sites. The background contour surface shows the RCM04 model.

Within Switzerland we have, according to Fig. 2, variations of about 2.6 mm/yr (northern stations almost sinking compared to the average movement; biggest uplift for the sites of the central Alps) derived from GNSS and variations of 1.5 mm/yr derived from levelling. The GNNS-derived vertical movement of JUJO is larger than the movement of the neighboring stations (relative to Zimmerwald close to Berne a vertical uplift of 1.1 mm/yr is computed – with 1 year less data we stated 1.7 mm/yr in the report for 2008), but compared with other AGNES stations the time series of JUJO are quite noisy (especially in the height). Up to now we have no explanation for that – possibly it is due to the special radom construction of the antenna or it is due to quite high electromagnetic radiation of the near telecommunication lines.
In general, the determination of the vertical movements derived from GNSS and levelling demonstrates that the Alps are still rising. Nevertheless, the GNSS-derived rates are determined 60-80% higher than the levelling-derived rates.

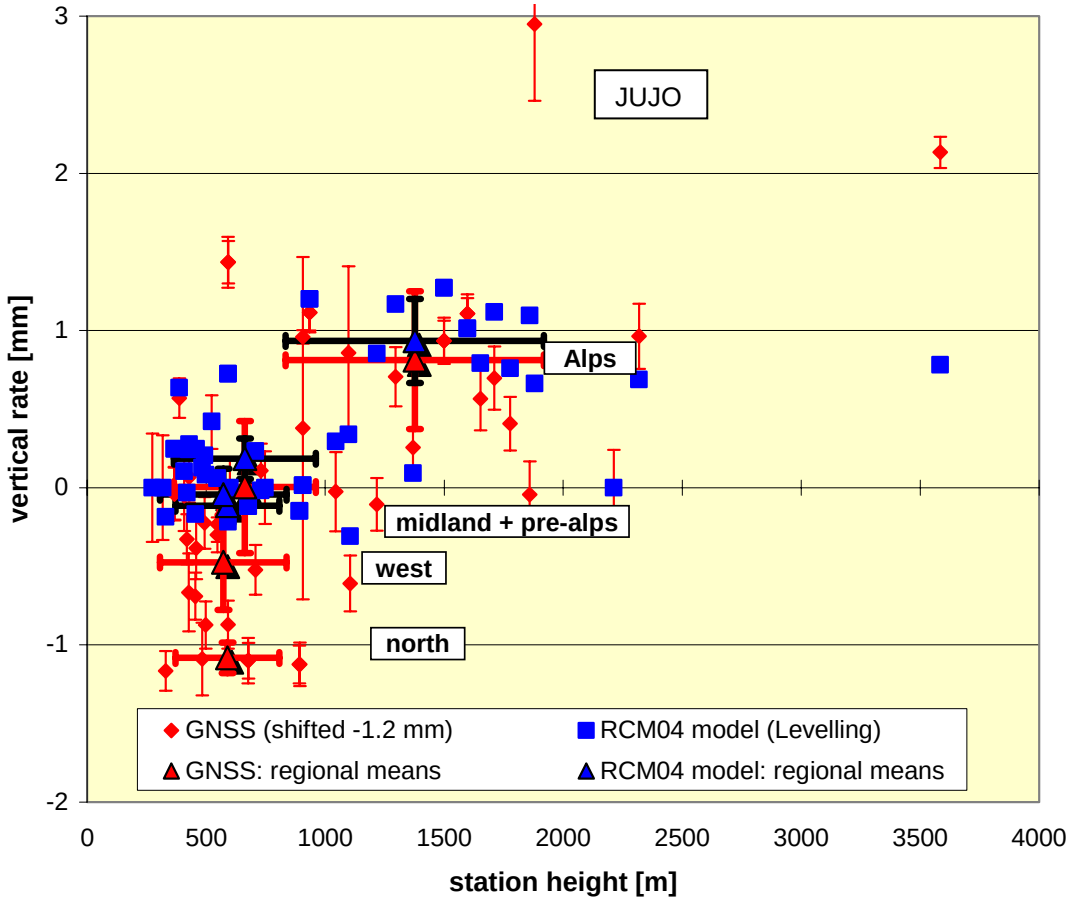

Fig. 2: Vertical uplift of the stations as a function of the station height (red: GNSS, blue: Levelling).

Key words:

GPS, GLONASS, GNSS, Meteorology, Positioning, Integrated Water Vapour, Zenith Path Delay, GPS Tomography, Geotectonics

Internet data bases:

http://www.swisstopo.ch/pnac; http://egvap.dmi.dk/

Collaborating partners/networks:

Astronomical Institute (AIUB), University of Berne
MeteoSwiss, Zurich and Payerne
Institute of Applied Physics (IAP), University of Berne
Institute of Geodesy and Photogrammetry, ETH Zürich
E-GVAP II (EUMETNET GPS Water Vapor Programme)

Scientific publications and public outreach 2009:

Refereed journal articles and their internet access

Dach R., E. Brockmann, S. Schaer, G. Beutler, M. Meindl, L. Prange, H. Bock, A. Jäggi, L. Ostini (2009): GNSS Processing at CODE: Status Report. Journal of Geodesy, Volume **83**, Issue 3, Page 353, 2009.

Conference papers

Brockmann E., D. Ineichen, M. Kistler, U. Marti, S. Schaer, A. Schaltter, B. Vogel, A. Wiget, U. Wild (2009): National Report of Switzerland: New Developments in Swiss National Geodetic Surveying. In: Ihde, J. and H. Hornik (Eds): Subcommission for the European Reference Frame (EUREF), Firenze, 2009 (in prep.).

Brockmann E. (2009): EUREF-TWG Project: Monitoring of official national ETRF coordinates on EPN web. In: Ihde, J. and H. Hornik (Eds): Subcommision for the European Reference Frame (EUREF), Firenze, 2009 (in prep., submitted to BGG)

Schaer S., E. Brockmann, M. Meindl, G. Beutler (2009): Rapid Static Positioning Using GPS and GLONASS. In: Ihde, J. and H. Hornik (Eds): Subcommision for the European Reference Frame (EUREF), Firenze, 2009 (in prep., submitted to BGG).

Brockmann E., D. Ineichen, U. Marti, S. Schaer, A. Schlatter, A. Villiger (2009): Determination of Tec-tonic Movements in the Swiss Alps using GNSS and Levelling, Proceedings of the IAG Symposium in Buenos Aires 2009 (in prep.)

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