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.
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).

Last activities

Due to the extreme altitude, the station is not optimal for real-time positioning applications. Therefore, an additional station was built in Hasliberg (September 2006), which is used for real-time positioning, whereas the Jungfraujoch site is used for all scientific applications.
In summer 2007, AGNES was enhanced with the Russian navigation system GLONASS. At the Jungfraujoch station, the receiver was replaced on July 2 by a new combined GPS/GLONASS receiver of type Trimble NETR5. The antenna was not replaced due to the special construction with the circulation of warm air in order to keep the antenna ice-free. Therefore, still GPS-only data are collected at Jungfraujoch. Due to the bigger number of tracking channels of the new receiver, the previous limitation of maximally 12 simultaneously tracked GPS satellites could be eliminated.

GNSS-Meteorology

An important scientific application is GNSS-meteorology. From the permanent 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; started 2006) is to operationally use these data for numerical weather predictions. Therefore, MeteoSwiss and other European meteorological institutes are deeply involved in these activities.
Whereas MeteoSwiss is using the data not yet in the operational assimilation runs, MeteoFrance is using these new data types already routinely for their numerical

weather prediction. Figure 1 gives an overview of the status of the availability of ZTD products on Jan., 9, 2009 for Europe. swisstopo analyses on an hourly basis approximately 90-100 stations of this network.

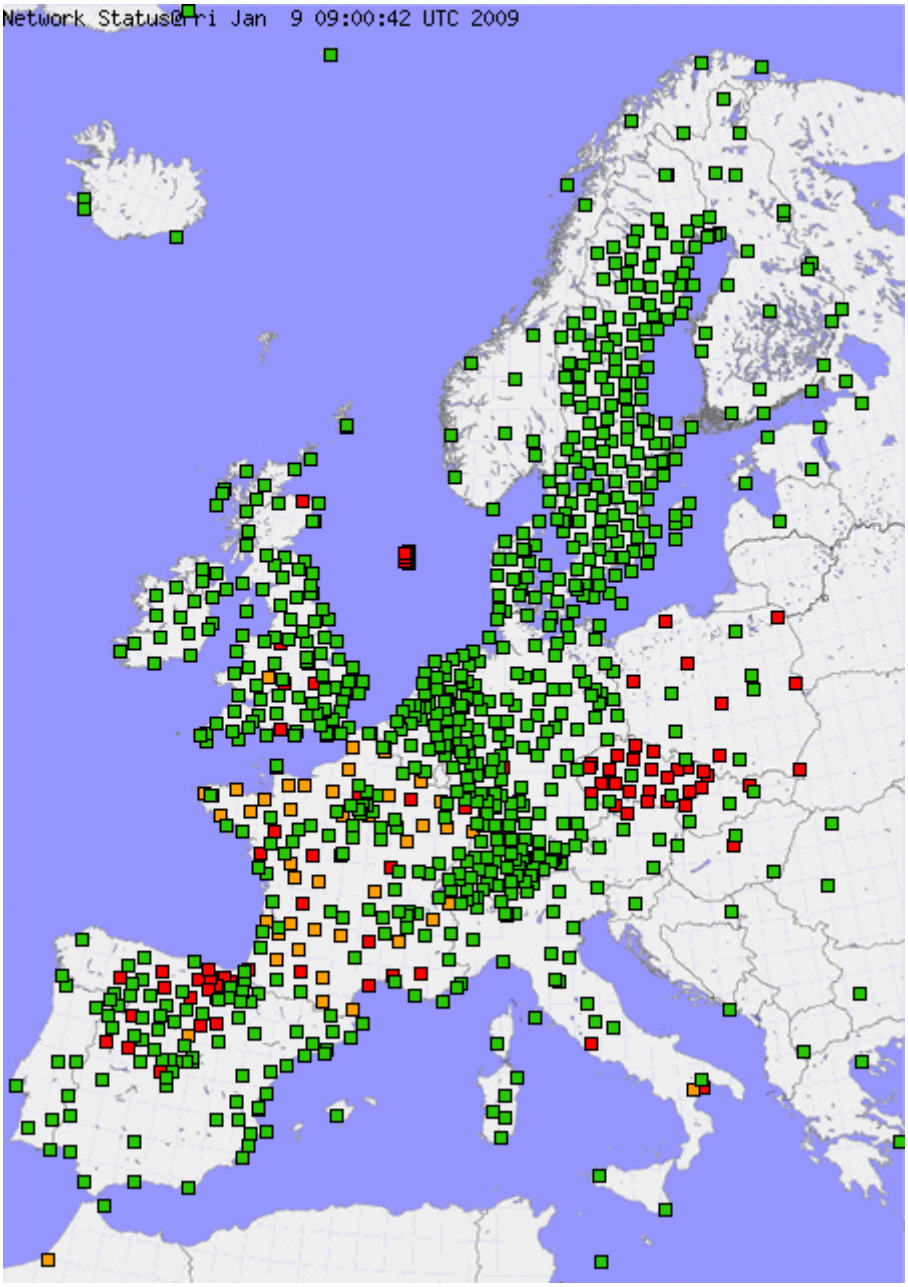

Fig. 1: Jungfraujoch permanent GNSS station is the highest station of roughly 600 permanent European GNSS stations. The orange and red colors indicate data delays of several hours or days.

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.

Figure 2 shows the time series of weekly coordinate estimates for the 54 km baseline between Jungfraujoch (JUJO) and the next AGNES station located in Zimmerwald (ZIMM). Horizontally, the movements between the two sites are with 0.3 mm / year very small. Slightly bigger is the vertical movement difference between the two sites of roughly 1.7 mm per year (JUJO moves up compared to ZIMM).

The coordinate estimates seem very reliable, 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.

The GNSS applications provide results for a quite big geographic area within Europe. If we compare the movements of all processed stations in an (assumed as stable) European reference frame, we see quite significant vertical movements of all stations of the alpine area (see Figure 3). Here, JUJO moves with one of the largest vertical "velocities" of the AGNES stations.

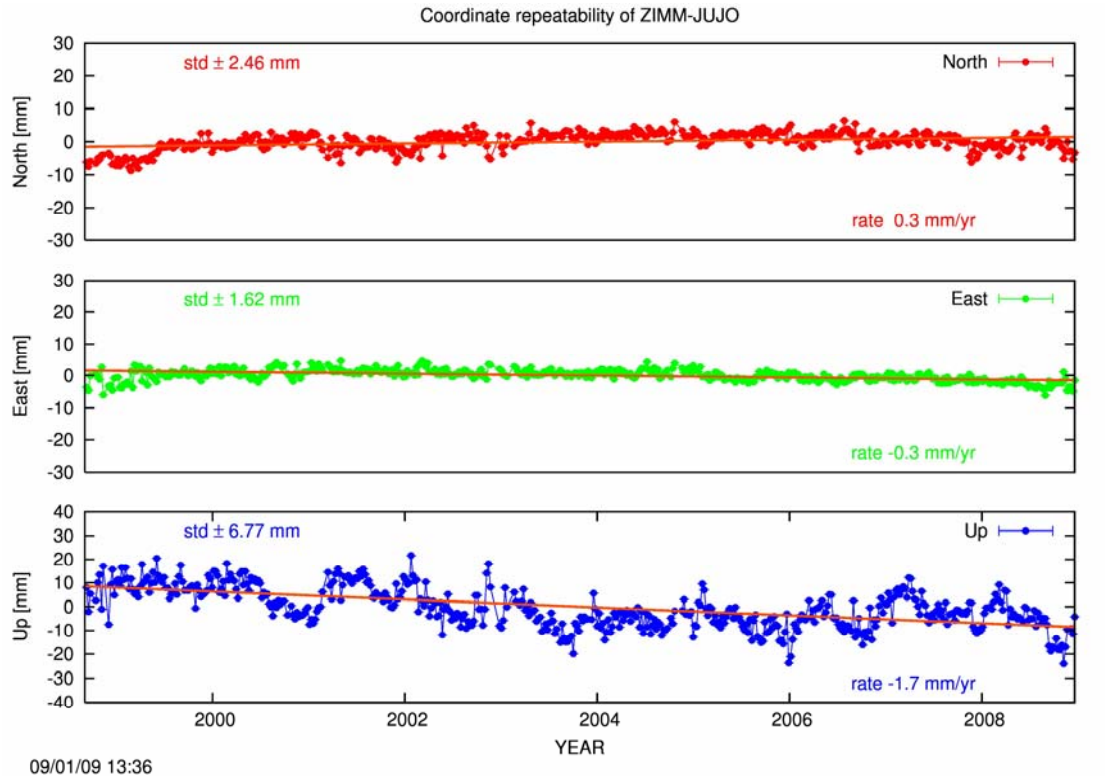

Fig. 2: Coordinate time series (north, east, and up component) of the baseline ZIMM-JUJO (JUJO selected as reference station).

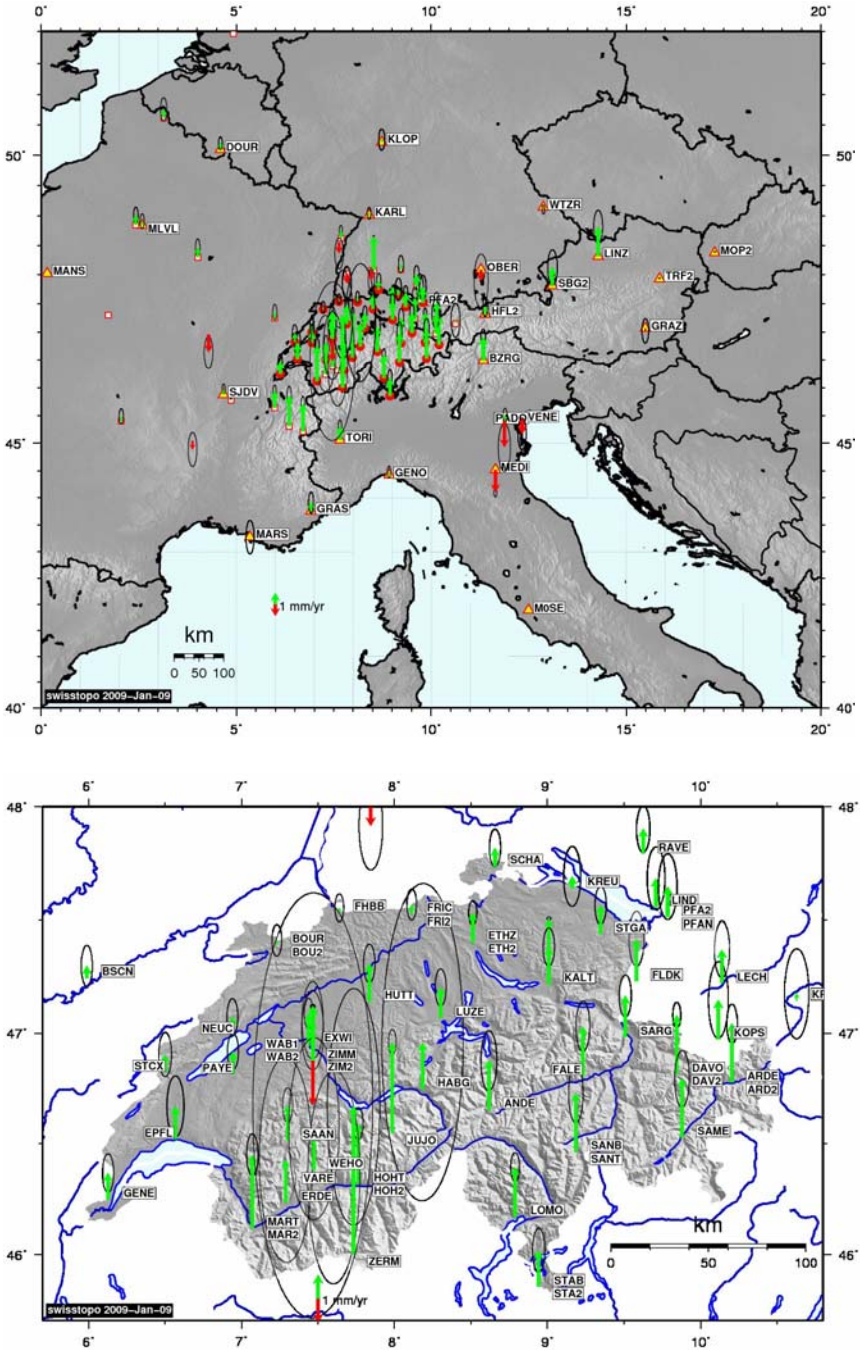

Fig. 3: Vertical velocities of AGNES stations (upward velocity in green, downward velocity in red) with respect to the stable European part (upper diagram) and for the area of Switzerland (lower diagram).

The station ZIM2, the GPS/GLONASS twin station of ZIMM, seems to move downwards. Despite the short time series of only one year, settlement effects seem to be responsible for the only sinking Swiss station (-4 mm per year relative to ZIMM).
The fact that the Swiss Alps are still rising is already known since several years from the analyses of leveling 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. Similar results can be achieved now with the analyses of 10 years of permanent GNSS data.

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 (EUMETNET GPS Water Vapor Programme)

Scientific publications and public outreach 2008:

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 (2008), GNSS Processing at CODE, Journal of Geodesy – IGS special issue, accepted for publication Oct., 14 (DOI 10.1007/s00190–008–0281–2), 2008.

Conference papers

Brockmann E., D. Ineichen, M. Kistler, U. Marti, A. Schaltter, B. Vogel, A. Wiget, U. Wild (2007): 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), Brussels, 2008 (in prep.).

Ineichen D., E. Brockmann, S. Schaer (2008): Processing Combined GPS/GLONASS Data at swisstopo's Local Analysis Center. In: Ihde, J. and H. Hornik (Eds): Subcommision for the European Reference Frame (EUREF), Brussels, 2008 (in prep.).

Pottiaux, E., E. Brockmann, W. Soehne, C. Bruyninx (2008): The EUREF - EUMETNET Collaboration: First Experiences and Potential Benefits. . In: Ihde, J. and H. Hornik (Eds): Subcommision for the European Reference Frame (EUREF), Brussels, 2008 (in prep), also published in Bulletin of Geodesy and Geomatics (BGG) edited by F. Sanso (in prep).

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