Name of research institute or organization:

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

Title of project:

Automated GNSS Network Switzerland (AGNES)

Project leader and team:

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Project description:

The station is part of the Automated GNSS Network of Switzerland (AGNES) consisting of 31 sites, equipped with GNSS receivers and antennas. In Spring 2015, the complete AGNES network, with the exception of Jungfraujoch (see later), was enhanced from GPS and GLONASS (the Russian equivalent of GPS) to a Multi-GNSS network which is capable to track also satellites of the European Galileo System and the Chinese BeiDou System.

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 station JUJO is mainly contributing to scientific applications. Troposphere path delays derived from the swisstopo processing are provided to MeteoSwiss on an hourly basis. Furthermore, the data are sent to the European meteo community EUMETNET, where the data are available for all meteo agencies for numerical weather predictions. At the moment, UK METO, MeteoFrance, DMI, and KNMI are using the GNSS-derived troposphere models routinely in the weather forecasts. This activity is coordinated by the EGVAP project. The results are also sent to the Institute of Applied Physics (IAP) of the University of Berne where the data contribute to the STARTWAVE database. It is worth mentioning that our final troposphere products (delivered with 1-2 weeks delay) are also used by PMOD/WRC Davos for the calibration of the pyrgeometer.

In 2013 the new COST project named GNSS4SWEC (Advanced Global Navigation Satellite Systems tropospheric products for monitoring severe weather events and climate) started. The focus of swisstopo’s investigations is the long-term behaviour of the troposphere parameters. Due to the fact that we re-processed all Swiss and European GNSS data since 1996 with a homogeneous set of modelling parameters, we have a first data set which might help to detect possible changes in water vapour over time. Till now, the time series suffered from software changes and also from modelling changes which resulted in “jumps” in the troposphere time series.

Due to the extreme weather conditions a special antenna is installed at Jungfraujoch – the GPS-only antenna, operating since 1999, was therefore kept and not changed by a more modern equipment when in 2008 the enhancement to GPS + GLO was realized. In August 2015 MeteoSwiss installed a completely new observation mast. The uninterrupted time series of the JUJO original antenna from 1999 till 2015 was therefore stopped, because the new position is only on the decimetre level identical to the original position. With this change also the change of the GPS-only antenna to a Multi-GNSS was foreseen for 2015. The new station name assigned to the new location is JUJ2.

The new antenna was, similar to the existing antenna, integrated into the MeteoSwiss measurement system. Warm air is used to prohibit the antenna from ice on top. All AGNES GNSS antennas were calibrated on a robot in Hannover to calibrate possible delays of the antenna phase centre in dependence of the elevation and azimuth a satellite is tracked.
Figure 1. Calibration protocol of the antenna of the JUJ2 station.

Fig. 1 shows an extraction of the calibration protocol. For the calibration it is important to calibrate the entire construction. Therefore, also a part of the connection to the mast was included to the antenna calibration.

Several problems caused a significant delay in a successful re-installation (delay in finishing the construction; delayed antenna calibration; installation without connecting the heating due to ice; malfunctioning antenna in March 2016; unsuccessful repair of the antenna in Switzerland). After a repair of the antenna beginning October 2016 in the US the antenna could successfully be installed on October 28, 2016 – see Fig. 2.

Fig. 3 shows the gap of data due to the re-installation of a new GNSS antenna on the new MeteoSwiss mast in the corresponding long-term coordinate time series.

Figure 2. Antenna repair on the MeteoSwiss observation mast.
Figure 3. Continuation of times series in October 2016 after a longer outage. Because of a complete new monumentation and a new antenna the new station will be operating under the name JUJ2.

JUJ2 is the last Swiss station which was enhanced to Multi-GNSS (all others already in spring 2015). This means that also signals of the European satellite system Galileo will be tracked as well as other new evolving satellite systems Beidou (China) and QZSS (Japan). As an example some figures in Fig. 4 show the available signals.

Figure 4. Satellite signals observed at station JUJ2 (after operation start doy-of-year 303: Oct. 29, 2016). Beside 31 GPS satellites and 23-24 GLONASS satellites 10 BeiDou and 10 Galileo satellites are tracked between October 29 and November 15, 2016 (DOY 320).
Figure 5. Various troposphere parameter estimates (after re-installation). Missing data of hourly processing on DOY 305 are due to internet connection problems. Daily solutions (LPT PP), performed in a post-processing mode later, are not concerned (black dots).

Another example of results, this time with the focus on troposphere estimates, is given in Fig. 5.

Differences between coordinates and troposphere parameters derived from the different satellite systems are displayed in Fig. 6. No significant systematic biases are visible.

Further results of the processing are available online (updated hourly): http://pnac.swisstopo.admin.ch/pages/en/qsumjuj2.html

We hope that this link will be available for several years. In summer 2016 the complete web-based monitoring system, established in 2001, was changed to a new location.
Figure 6. Daily Intersystem parameters (differences of the coordinate and troposphere results of GLONASS (R), Galileo (E) and BeiDou (C) with respect to GPS (G)).

Key words:
GPS, GLONASS, GNSS, meteorology, positioning, integrated water vapour, zenith path delay, GPS tomography, geotectonic

Internet data bases:
http://www.swisstopo.ch/pnac ; http://egvap.dmi.dk/ ;
http://www.iapmw.unibe.ch/research/projects/STARTWAVE/

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 Vapour Programme)
GNSS4SWEC (COST EU project)

Scientific publications and public outreach 2016:

Refereed journal articles and their internet access

Conference papers
Brockmann, E., swisstopo Report for EGVAP 2016, EGVAP expert meeting, Copenhagen, Denmark, December 6-7, 2016.

123
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