

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 Jungfrauoch (JUJO) (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 multi-purpose 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. Currently, a continuation of this EUMETNET project is planned. 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 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. With a complete reprocessing of all data from 1996 – 2014 a long time span is covered with identical modelling of observations. This modelling is also continued till today. Nevertheless, antenna changes at stations have a significant influence to the long-term consistency (e.g. also the new Jungfrauoch mast installation and the new antenna which is capable to track all modern GNSS satellite system whereas the old antenna was only capable to track GPS). The GNSS4SWEC project is about to finish 2017. The final report will be drafted 2018. Below we show some figures, showing the troposphere long-term data of JUJO (GPS-only) and JUJ2 (Multi-GNSS).

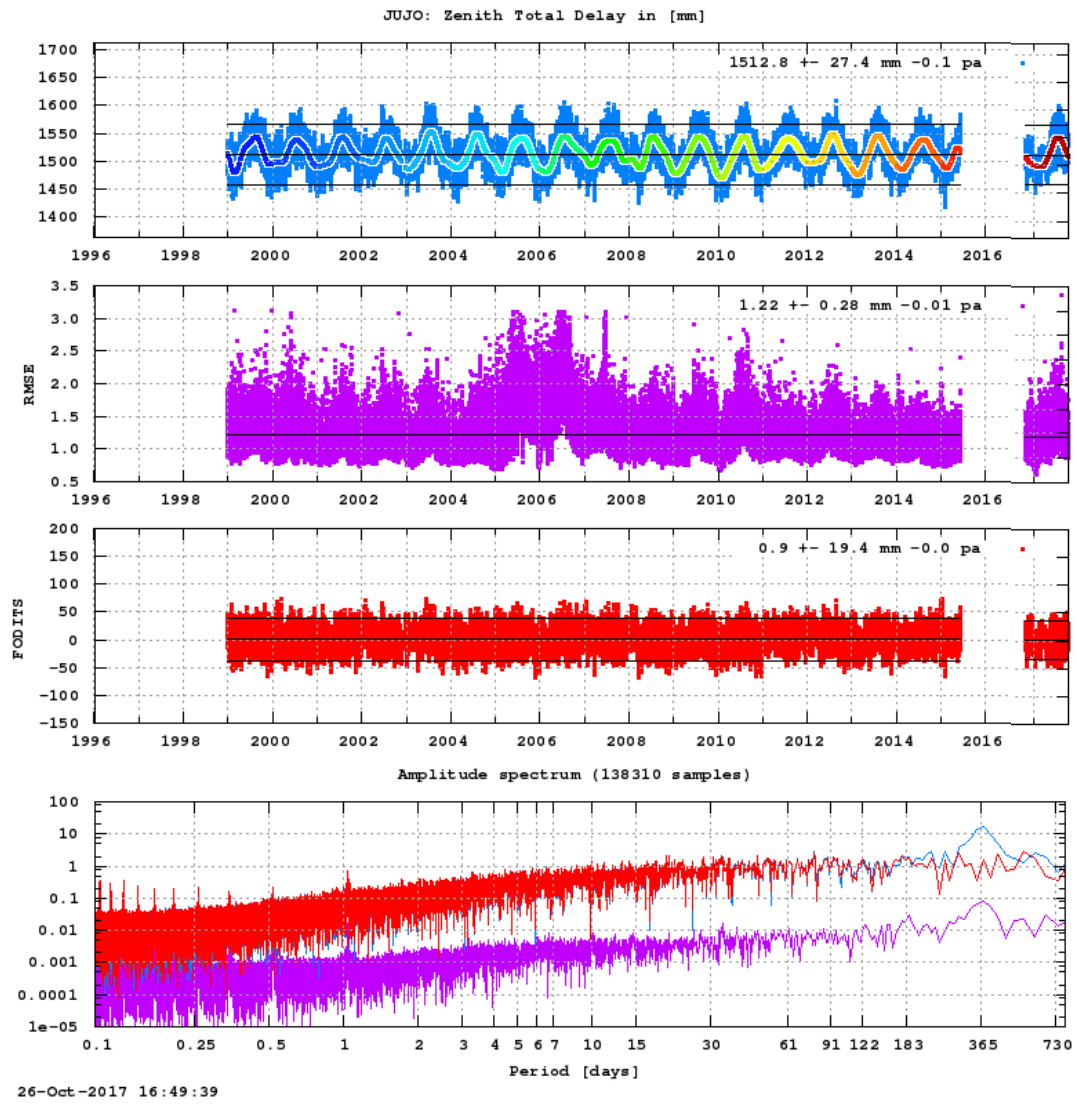


Figure 1. Long-term troposphere estimates for JUJO / JUJ2.

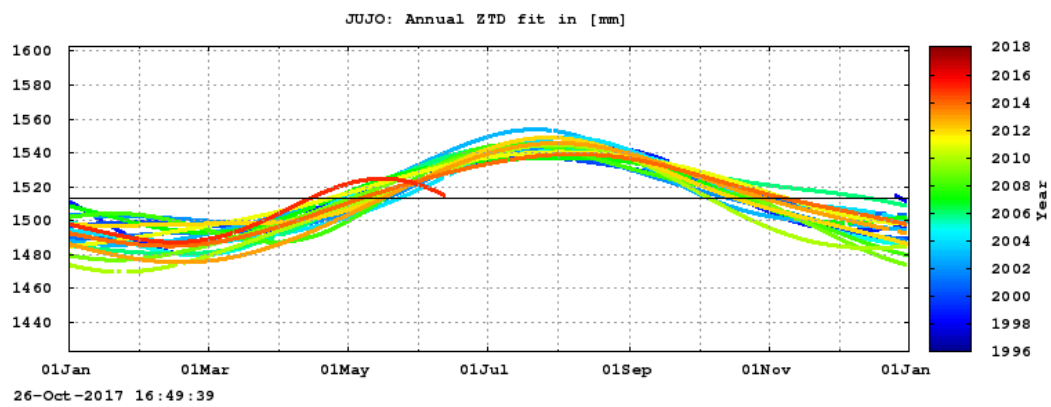


Figure 2. Annual fit of troposphere parameters (JUJO).

Fig. 1 shows the long-term troposphere estimates for JUJO and JUJ2 (after the interruption), its internal formal errors (RMS) and the corresponding amplitude spectrum. The annual variations are obvious. The signal was fitted with a fourier function and the annual fits are then shown in Fig. 2.

Coordinate time series in the local system North, East and Up of JUJO/JUJ2 are shown in Fig. 3. The annual signal in the up component is visible in the amplitude spectrum, but with 2 mm not significant. The time series covers data from 1999 till 2017 – totally 18 years. Only stations like the reference station in Zimmerwald (ZIMM) cover a longer time span of 22 years.

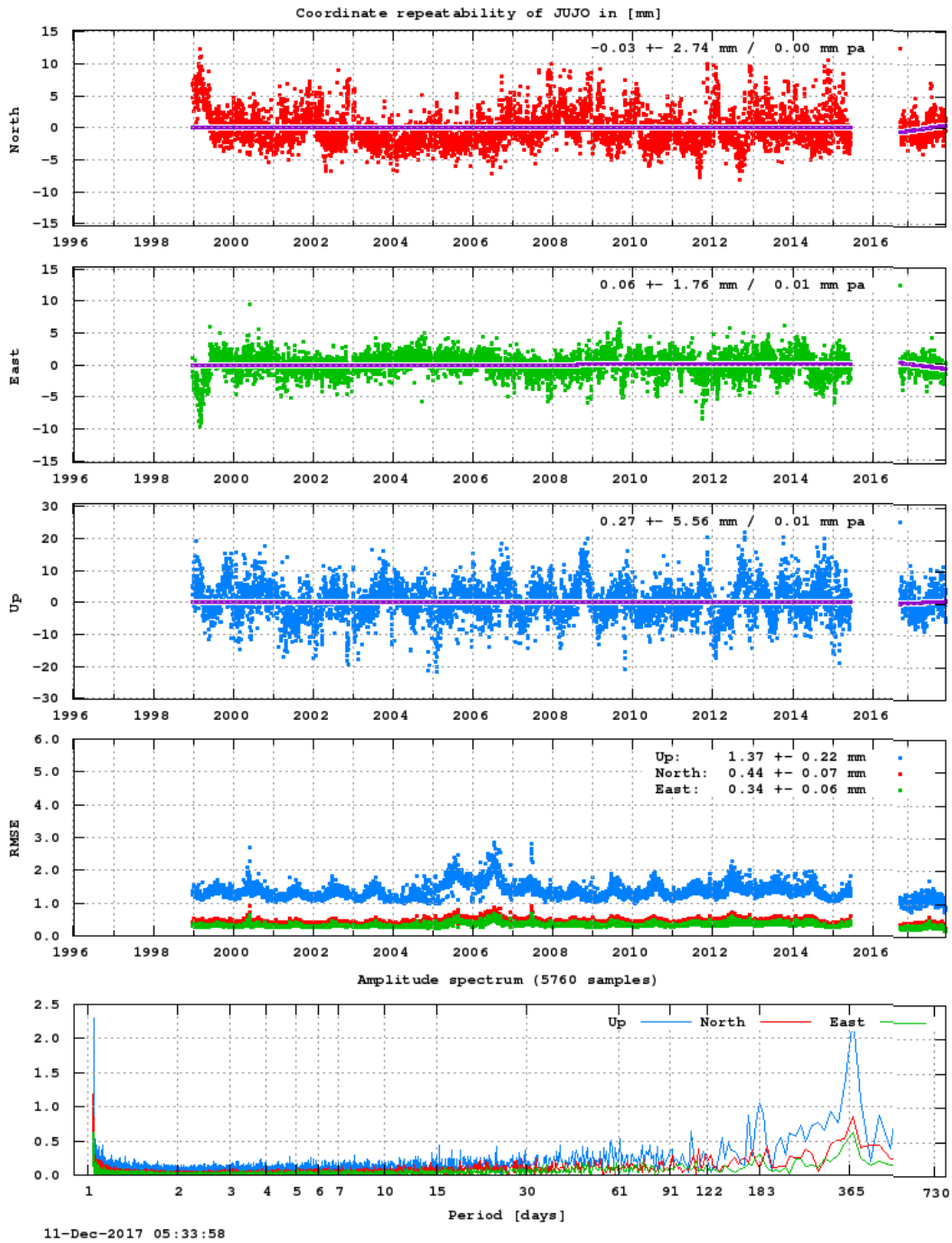


Figure 3. Long-term time series of JUJO/JUJ2.

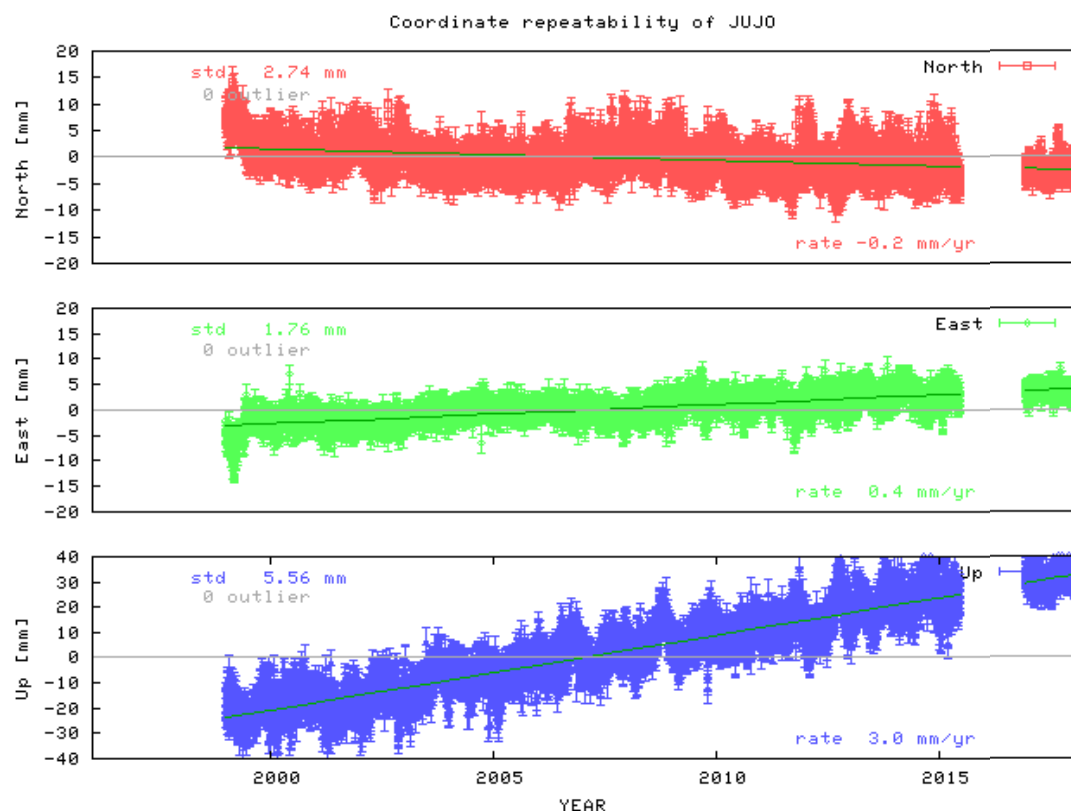


Figure 4. Long-term time series of JUJ0/JUJ2 with estimated velocities applied.

The estimated station velocity is not applied in Fig. 3. When plotting the time series including the estimated velocities in Fig. 4, the uplift of about 3 mm/yr with respect to the European plate is clearly visible. Since 1999 the station increased its elevation by 5.4 cm. Also other Alpine sites of the AGNES permanent network show an uplift, but usually well below 2 mm/yr.

Further results of the processing are available online (updated routinely):

<http://pnac.swisstopo.admin.ch/pages/en/qsumjuj2.html>

Key words:

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

Internet data bases:

<http://pnac.swisstopo.admin.ch/>
<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 2017:

Refereed journal articles and their internet access

Pacione, R., A. Araszkiewicz, E. Brockmann, J. Dousa, EPN Repro2: A reference GNSS tropospheric dataset over Europe, *Atmos. Meas. Tech.*, **10**, 1–17, doi: 10.5194/amt-10-1689-2017, 2017.
<https://www.atmos-meas-tech.net/10/1689/2017/>

Conference papers

Brockmann, E. et al., National Report of Switzerland, EUREF-Symposium, Wroclaw, Poland, May 17-19, 2017.

Brockmann, E., S. Lutz, D. Ineichen, S. Schaer, Multi-GNSS developments for the EPN and for the Swiss networks, EUREF-Symposium, Wroclaw, Poland, May 17-19, 2017.

Brockmann, E., S. Lutz, D. Ineichen, S. Schaer, Impact of Multi-GNSS analysis on precise geodetic applications, IAG-IASPEI scientific Assembly, Kobe, Japan, July 30 – August 4, 2017.

Brockmann, E., swisstopo Report for EGVAP 2017, EGVAP expert meeting, De Bilt, Netherlands, November 28-29, 2017.

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