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PPP or network solution for detection of surface displacements?

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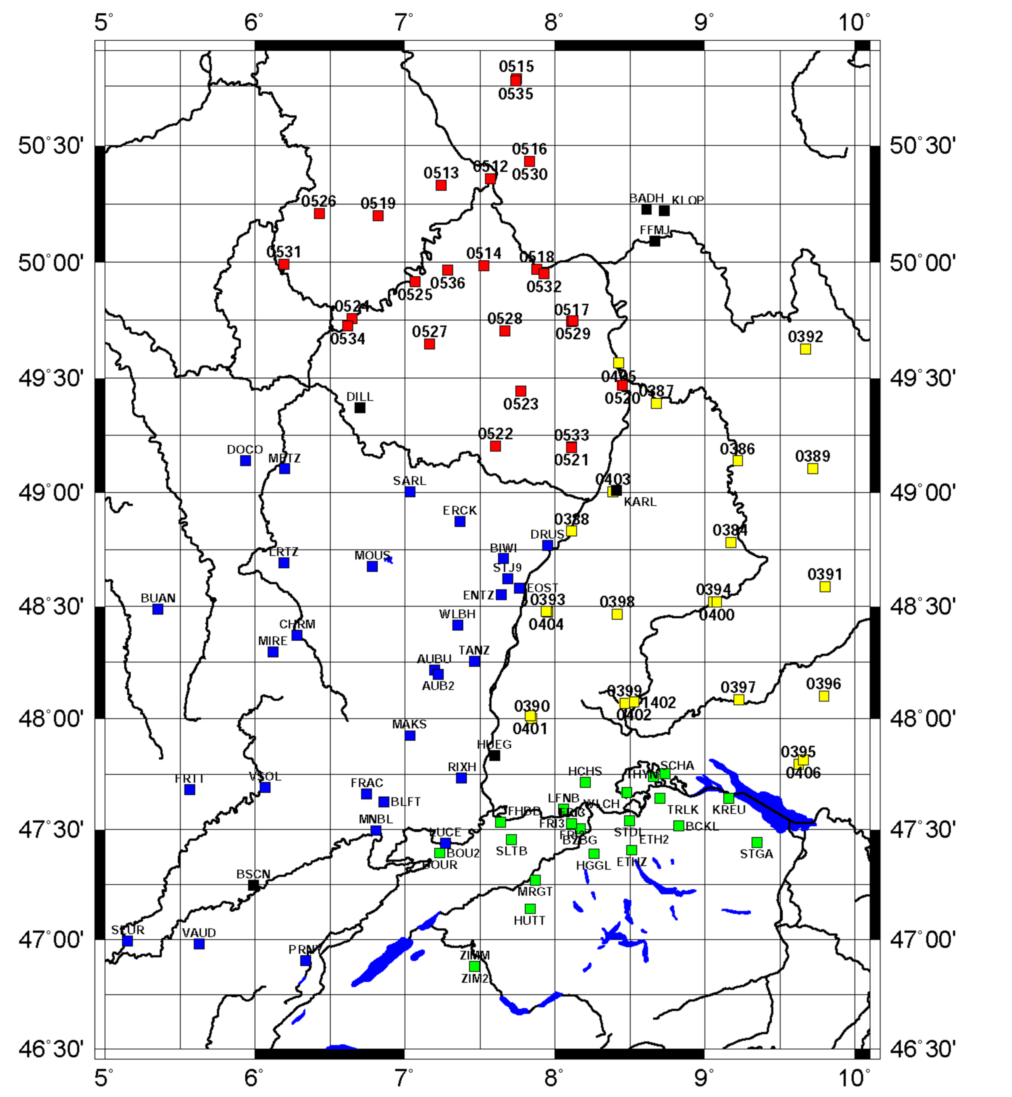
Motivation

Detection of the recent crustal deformation of the Upper Rhine Graben (URG), which is part of the European Cenozoic rift system, is of interest for geoscience research. For this purpose, the network GURN (GNSS Upper Rhine Graben Network) of approximately 100 stations was established as a transnational cooperative project.
The GPS observations acquired at these sites between 2002 and 2016 have been processed in different methods applying state-of-the art strategies and parameters. The resulting GPS coordinate time series have been analysed in order to extract the surface velocities for horizontal and vertical components.
In this research, we will discuss the results by using different strategies of GNSS data reprocessing: PPP (Precise Point Positioning) compared to network solution based on double-difference strategy (DD). Advantages and disadvantages of both solutions for this kind of GNSS application – intraplate deformation – I is presented. The velocity of the height component is also compared with the results of levelling data.

Processing Strategy

GURN data set has been collected from 109 stations over the time period between 2002 and 2016.



In the first step, the dual-frequency data of these sites was processed using Bernese GNSS Software 5.2. The Bernese processing engine for double difference processing, denoted as RNX2SNX, was applied to the dual-frequency GPS observations with 300 s sampling rate to calculate the network-solution. PPP solution was performed by using WaSoft. The strategy, parameter and used products are summarized in the table below.

Strategy	PPP	Network solution (DD)
Software	WaSoft	Bernese 5.2
Observables	GPS Dual-frequency code and carrier phase measurements	GPS Dual-frequency code and carrier phase measurements
Clock & Orbit	CODE (final)	CODE (final)
Troposphere (priori models & mapping functions)	GMF Saastamoinen (with GPT modell)	(dry and wet) VMF1 with ECMWF–based ZPD corrections
Elevation mask	> 10°	> 3°
Antenna calibration	IGS08 & individual callibrations for some antennas	IGS08 & individual callibrations for some antennas
Reference stations (IGS)	-	BOR1, GRAZ, HERT, LROC, MATE, ONSA, POTS, WSRT and WTZR

In the second step, the outliers of the daily coordinate time series have been detected and removed by applying a median filter. Cats program is used to estimate the linear trends in addition to the spectral index plus the amplitudes of white and power-law noise in the North, East and Up components assuming an annual and semi-annual signal. The results of Cats are the mean velocities in North, East and Up components and corresponding uncertainties.
Nine sites (0516, 0517, 0533, 0534, 0535, 0536, 1402, FRI2 and BIWI) are excluded from the further processing, because the time span of observations is less than two years or the coordinate time series are too noisy.

Horizontal surface displacements

In order to obtain the relative movements of the URG region, a local Euler pole from the velocities at the 100 sites using the two solutions is estimated. The table on the right shows the estimated Euler pole parameters for the URG region and the corresponding standard deviations comparing to ITRF08. The local Euler pole is located close and northeast to the ITRF08. Both solutions, network and PPP, show approximately similar parameters of the Euler pole.

Fig. 1 shows the horizontal velocities at the 100 sites after subtraction the Eurasian trend based on the estimated Euler pole.

Parameters of Eulor Pole		φ_P [°]	λ_P [°]	ω [°/Ma]	Standard deviations of φ_P	Standard deviations of λ_P	Standard deviations of ω
Local	Network solution	59.077	268.874	0.278	$4.7 * 10^{-10}$	$6.6 * 10^{-11}$	$5.3 * 10^{-10}$
Local	PPP	60.136	271.976	0.285	$5.3 * 10^{-10}$	$7.5 * 10^{-11}$	$6.0 * 10^{-10}$
ITRF08		54.225	261.165	0.257			

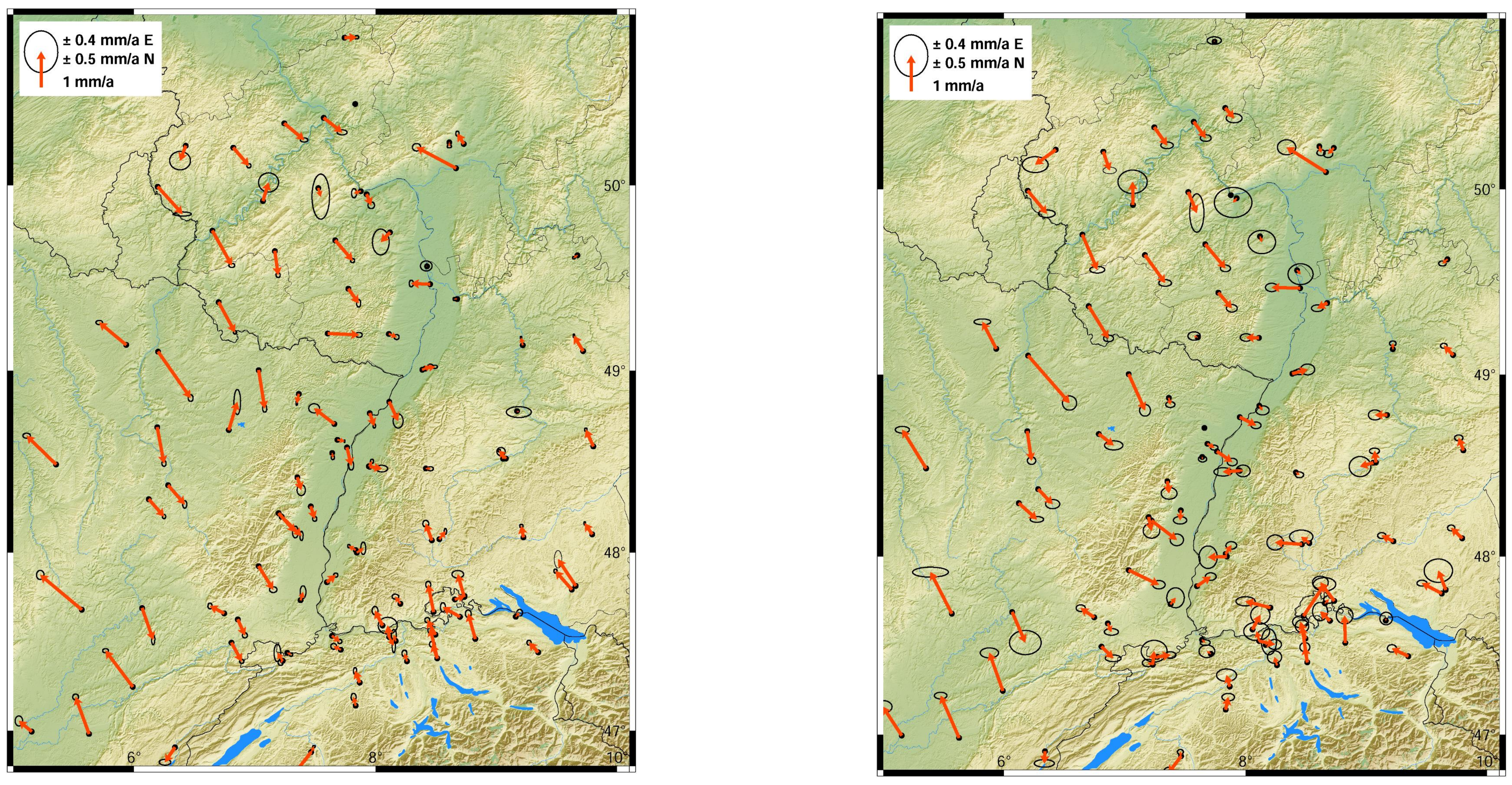


Fig. 1 Horizontal velocities and the confidence ellipses corresponding to the standard deviations at 100 sites. Whereas the network solution is shown on the left panel, the PPP solution is given on the right panel.

Vertical surface displacements

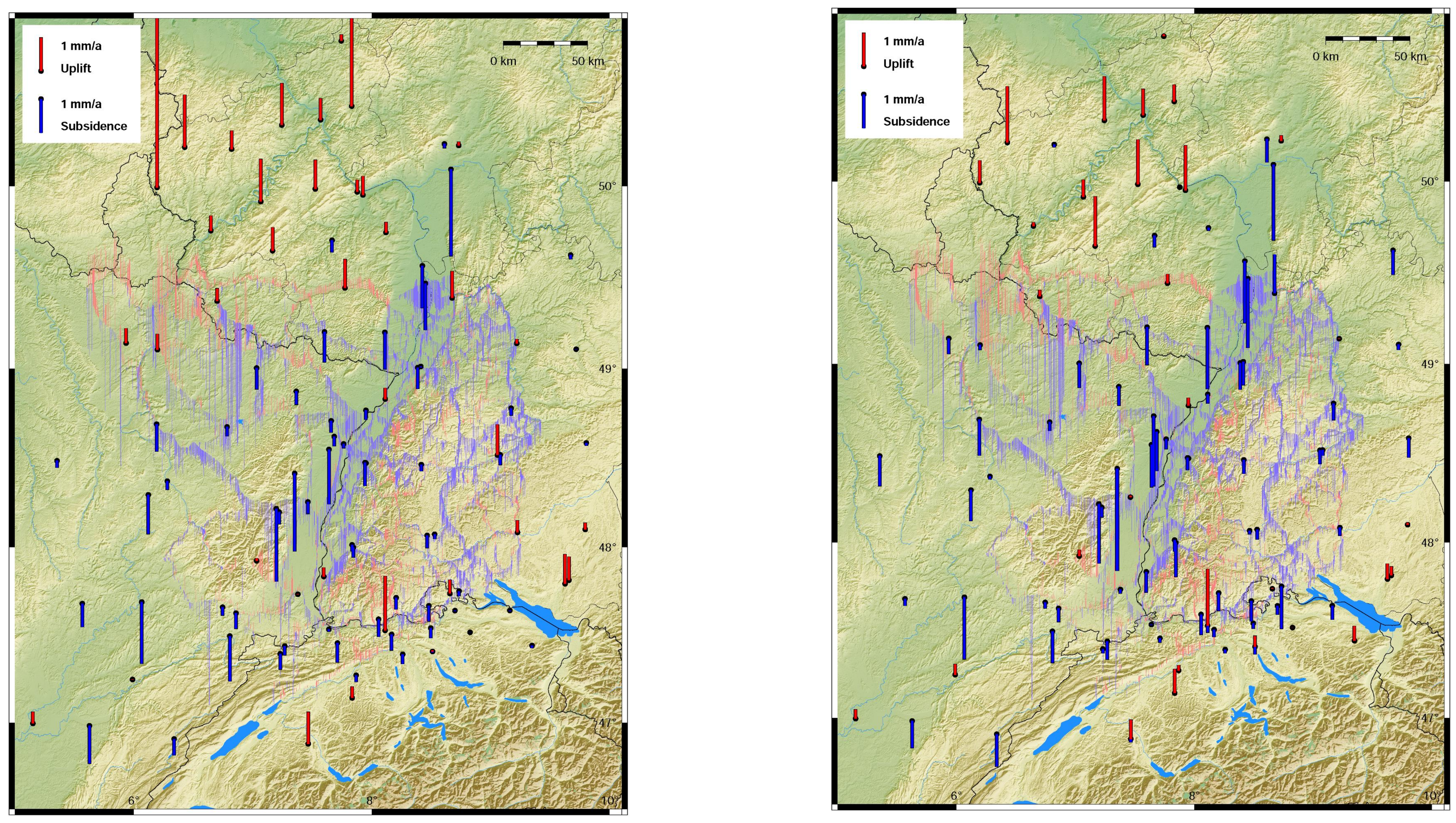


Fig. 2 The estimated Up-velocities by Cats for both solutions with the vertical rates estimated from levelling. Whereas the network solution is shown on the left panel, the PPP solution is given on the right panel.

Conclusion

- Network solution presents homogeneous horizontal displacements for sites which are located near each other (Fig. 1). This solution is more accurate than the PPP solution (see the differences in the confidence ellipses). PPP solution seems to be free from the correlation between stations.
- Both solutions show similar vertical displacements which are agreed with the results of leveling. Using network solution, some stations display a big vertical displacement more than 1.6 mm, which needs further investigations (Fig. 2).

Main References

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