GURN (GNSS Upper Rhine Graben Network): Research Goals and First Results

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Summary

In April 2008 the Institut de Physique du Globe de Strasbourg (Ecole et Observatoire des Sciences de la Terre) and the Geodetic Institute of the University Karlsruhe (TH) established an international cooperation called GURN (GNSS Upper Rhine Graben Network). Within the GURN initiative these institutions are cooperating in order to carry out research in the framework of the transnational project TOPO-WECEP (West and Central European Platform), which succeeds the former project EUCOR-URGENT (Upper Rhine Graben Evolution and NeoTectonics). The proposed research is based on GNSS (Global Navigation Satellite Systems) in order to detect recent crustal movements.

Acknowledgments: GURN put together the GPS data provided by a lot of public institutions and private companies. We thank all the people who contribute the acquisition of the data in Germany and in France and allow their use for scientific purposes.

Geophysical Context

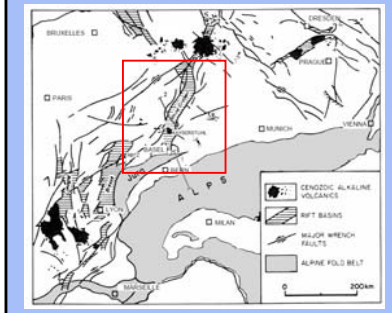


Figure 1: The European Cenozoic Rift System (ECRIS) in Europe. The red square indicates the GURN domain. Image modified from Ziegler (1992).

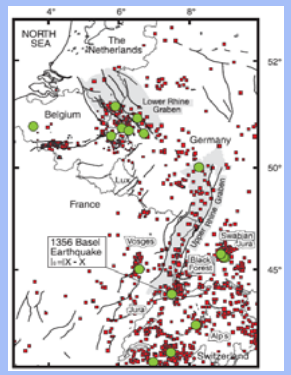


Figure 2: Seismotectonic framework of the Lower and Upper Rhine Graben. Squares depict the instrumental seismicity from 1910 to 1990 (1<M<5.5). Circles correspond to the historical seismicity (Meghraoui et al. 2001).

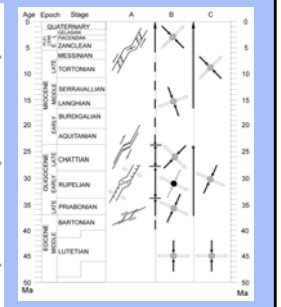


Figure 3: Time scale for the development of the Upper Rhine Graben rift system.
A- Kinematics of faults for the different phases of development of the graben (Schumacher 2002).
B- Stress conditions for the different phases as described by Schumacher (2002).
C- Development of the stress field as described by Michon et al. (2003). Figure from Lopes-Cardozo (2004).

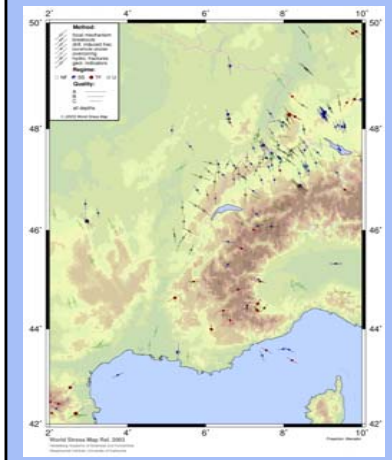


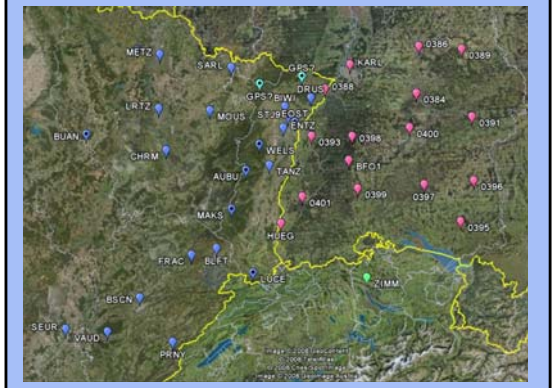
Figure 4: Map of the directions of maximum horizontal compression in the western Alpine foreland. Figure from Lopes-Cardozo (2004), obtained from the website of the World Stress Map project maintained at the University Karlsruhe (TH) (Link: www.world-stress-map.org).

The Rhine Graben is the central, most prominent segment of the European Cenozoic rift system (ECRIS, fig. 1) of Oligocene age which extends from the North Sea through Germany and France to the Mediterranean coast over a distance of some 1000 km. Within GURN the focus will be on the Upper Rhine Graben (URG). The URG is a 300 km long and 40 km wide SSW-NNE trending rift, extending from Basel (Switzerland) to Frankfurt (Germany), see fig. 2. It is limited to the west by the Vosges mountains and to the east by the Black Forest. The graben is bounded to the north by the uplifted area of the Rhenish Massif. To the south, the Leymen, Ferrette and Vendlincourt folds represent the northernmost structural front of the Jura fold and thrust belt. This thin-skinned compressive deformation front would propagate 30 km farther to the north up to Mulhouse (France).

Preceded by late Cretaceous volcanism, the rifting was initiated during Late Eocene to early Miocene (42-31 Ma) starting with broadly east-west or ENE-WSW extension and lasted until Aquitanian time (fig. 3). Today, the southern end of the Rhine Graben is characterized by small uplift and subsidence rates (Mälzer 1986) and by a quasi-compressive, left-lateral strike-slip tectonic regime (fig. 3), with a maximum stress-axis oriented NW-SE (fig. 4).

The URG is considered to be the most seismically active region of northwest Europe with significant probability for the occurrence of large earthquakes. For a better understanding of the processes that lead to seismic activity in the URG, it is necessary to study not only the location of the faults but also their kinematics. Seismic hazard assessment in the region are hindered by a lack of information on the movements of the active structures.

GURN: GNSS Upper Rhine Network



GURN includes actually German and French continuous GPS sites.

French sites have several origins: RENAG (Universities and research institutes), RGP (network of IGN), Teria, Orpheon. EOST sites are underlined by a black dot.

Most data of the German sites are provided from SA*POS*®-Baden-Württemberg.

In the future it is planed to include other SA*POS*® sites (SA*POS*®-Rheinland-Pfalz) and data from Switzerland (Swisstopo, ETH Zürich).

Goals of GURN

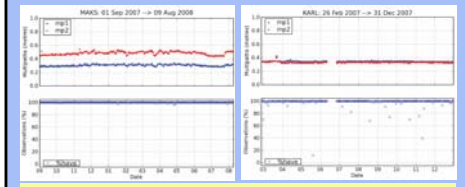
The primary goal of the GURN project as a long term project is to obtain precise estimations of horizontal and vertical movements of the area under research.

In the beginning of this project all available data of permanently observing GNSS sites have to be checked, in order to evaluate the data quality and to be able to select suitable sites and data processing strategies.

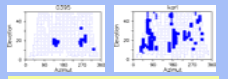
The GNSS-related research aims within GURN are:
- Near: Automated web-based presentation of results in near real-time
- Near: Generation of highly precise daily GURN solutions, starting 1st Jan. 2008.
- Near: Carrying out investigations in order to achieve an improved stochastic GNSS modeling, (keywords: site specific error handling, correlations, SNR-based)
- Far: Automated generation of extended water vapor fields
- Far: Revised geodynamic model of the URG area

The dense SA*POS*® network was established to guarantee point positioning for cadastral applications with an accuracy of a few cm.
If these sites should be used for highly precise geodynamical applications (Faulhaber 2007) the monumentation has to be validated.
The GIK monitored several SA*POS*® sites using additional sensors (e. g. tiltmeters).
At the SA*POS*® site Iffezheim (0388) a significant correlation between the behavior of the monument-based movement of the GNSS antenna and the external effect "filling level of the two ship locks" could be detected.

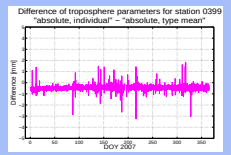
Verification of Data Quality – Methods and preliminary Results



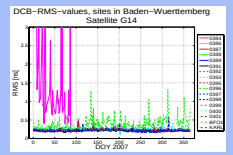
Using TEQC (UNAVCO) code-related multipath effects as well as the percentages of missing data of each site are quantified. This enables a preliminary quality classification of the GURN sites.



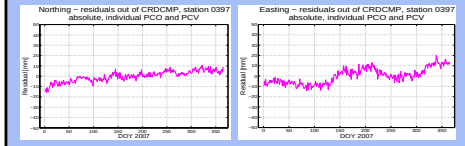
Analyzing the L3 residual time series of phase observations WaSoft/Multipath (link: www.wasoft.de) detects – under several assumptions – multipath effects of observation sites in order to improve the code-based quality classification of the GURN sites.
Legend: dot = observations; no dot = no observations; small rectangles = few multipath effects; large rectangles = large multipath effects.

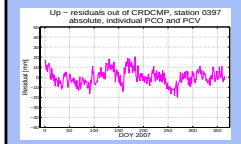


In contrast to the French sites, SA*POS*® sites are equipped with absolute calibrated antennas. The effects of an alternative antenna modeling on the estimation results were analyzed.

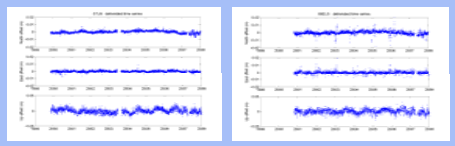


Values of differential code biases (DCB) calculated using the PPP module of the Bernese GPS Software enables to discover problematic site equipments.





Using PPP preliminary time series of all GURN sites were derived within the ITRF2005 (Altamimi et al. 2007), thus the Eurasian trend of the horizontal, local topocentric coordinates is clearly visible. Analyzing the time series (e. g. scattering) the quality classification could be improved.



Preliminary results:

The GPS data were analyzed using the GAMIT/GLOBK 10.33 version at Strasbourg IPGS.

These 3 figures present some of the longest time series of our GPS network: STJ9 is locating in the Rhine Graben at about 10 km of Strasbourg, France. WELS is located in the Vosges mountains. SJDV is another GPS station included in our processing SJDV is not located in the Upper Rhine Graben. Since 2007, the IGPS has installed 5 new continuous GPS stations (EOST, MAKS, LUCE, AUBU, BUAN) on the French side of URG or in the vicinity.