EPN Special Project on "Time series analysis … " Preliminary Results and Future Prospects

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Introduction

Thanks to the increasing number of permanent sites and the longer time series available (since January 1996) the EUREF Permanent Network (EPN) has become a valuable tool for the determination of present-day kinematics within Europe and its adjacent plates. However, the EPN was originally established for serving as an European regional geodetic reference frame and had site configurations primarily designed for this purpose. Because of the different requirements and the temporary performance problems at some stations (causing offsets, outliers in the time series), the sites are not always suitable to perform reliable geophysical interpretation. On its Tromsø meeting (21 June 2000), the EUREF TWG created a new EPN Special Project (SP) charged with the tasks to monitor the EPN weekly combined SINEX solutions and to analyze the EPN time series in order to further improve the station performance and network homegeneity to supply the EPN sites with ***up-to-date*** kinematic information. The basic idea behind the creation of this SP was to support the use of the EPN products for geokinematics by establishing an interface between geodesists and geophysicists.
The activity of the SP involves the following basic tasks:

- time series monitoring and correction, preparations for kinematic analysis,
- quality assessment and monitoring of site configuration,
- identification of stations with unreliable behavior.

The SP aims to supply users with site configuration information and monitor its correlation with the EPN time series. The SP members are performing careful overview of each EPN station encompassing the monumentation, environmental effects, equipment and the coordinate time series stability. This work would benefit from a uniform data quality assessment, therefore the SP would support the Network Coordinator and the Data Flow Coordinator in the elaboration of methods for EPN data quality monitoring.
Based on the results, a reliable station subset from the EPN will be selected and offered for geophysical studies. This subset may be used to link non-EUREF permanent stations or epoch-type kinematic networks to a uniform frame for more detailed studies at sub-regional (e.g. WEGENER, CERGOP) and national scales.
The SP description and the results of all activities may be found in the EPN CB website: (www.epncb.oma.be/series.html)

Project members:

The Project chairman is Ambrus Kenyeres, FÖMI Satellite Geodetic Observatory, Hungary. The members are the following:

Name	*Institute*	*Studied EPN Sub-region*
Hefty, J.	Slovak University of Technology (SUT)	Central Europe
Caporali, A.	University of Padova	Mediterranean/Dinarides
Ferraro, L.	Italian Space Agency (ASI)	Mediterranean/Dinarides
Jivall, L.	National Land Survey of Sweden	Fennoscandia
Poutanen, M.	Finnish Geodetic Institute (FGI)	Fennoscandia
Fernandes, R.	DEOS-TU Delft	Iberian Peninsula
Kosters, A.J.M.	Meetkundige Dienst of Rijkswaterstaat (RWS)	Western Europe
Stangl, G.	Observatorium Lustbuehel, Graz (OLG)	SE-Europe/Anatolia
Bosy, J.	Agricultural University Wroclaw (AUW)	Sudety/Central Europe
Bruyninx, C.	Royal Observatory of Belgium (ROB)	Western Europe
Brockmann, E.	Swiss Federal Office of Topography	Alps

Each member or group is concentrating on a selected subset of the EPN stations (see Fig.1) by closely following the events at the stations, processing of some additional non-EPN sites, monitoring the time series and identifying local events which may caused jumps and/or biases in the time series. The groups can perform geokinematic analysis for the respective region using the EPN sites as reference.

Figure 1. The EPN station subsets analyzed by the SP members.

Activities of the SP

a./ Multi-year combination analysis of the EPN weekly product

The multi-year combination and the station velocity estimation is done using the ADDNEQ program of the BERNESE V4.2 software package. The computations are based on the official EPN weekly combined solutions produced at the BKG. Observations before GPSWeek 860 were not taken into account, because of the coordinate jumps at several stations, caused by the change of the reference system of the orbits (held fixed in the EUREF solution) from ITRF93 to ITRF94 and the introduction of the new antenna phase eccentricity tables at this epoch.
The geodetic datum of the multi-year solution is defined by constraining (no translation, no rotation) the *ITRF2000 (epoch 2000.0)* coordinates and velocities of the following stations:

GRAS, GRAZ, HOFN, JOZE, KOSG, MATE, METS, VILL, ZECK.

The a priori site velocities are linked to the ITRF2000 however the estimated velocities may be considered more reliable and up-to-date as the ITRF2000 solution, while they are based on a longer time span including observations up to the latest available weekly combined solution. The resulting time series, displayed at the EPN CB website as the "*improved*" time series, are practically the N/E/Up coordinate differences between each weekly and the computed multi-year coordinate solution. This difference is computed after applying a 6-parameter Helmert transformation using the complete available network. The tilt in the time series **fully corresponds** to the residual velocity of each station, where the NNR-NUVEL-1A velocity is subtracted from the estimated values explicitly considering that each station is situating on the Eurasian (EURA) plate (see an example in Fig.3).

Within this Project, also the different combination techniques and the effect of the reference site configurations (see Fig.2) have been studied in detail.

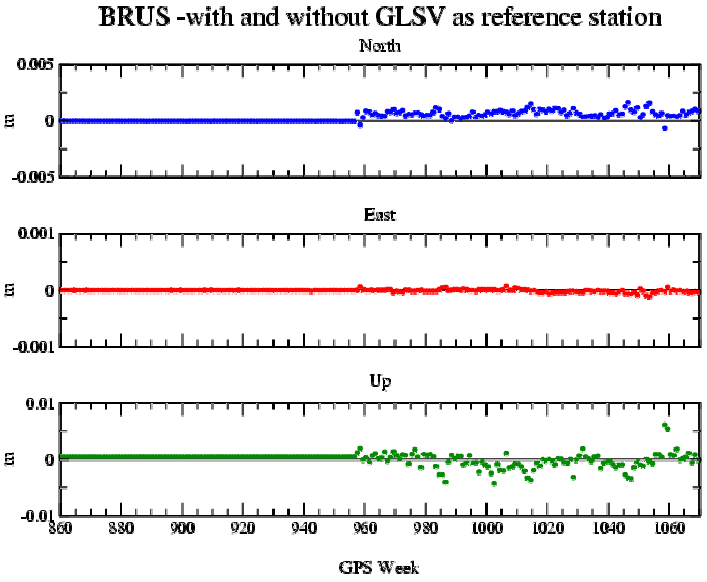

Figure 2. This example demonstrates the propagation of noise from one reference station to an other site, when a new reference site (GLSV) was introduced into the combination process. GLSV joined to EPN at GPS Week 956.

b./ Time series analysis

Environmental effects, equipment replacement, changes in the observation/processing strategy, receiver/antenna problems and weak monumentation may introduce temporary, sudden or periodical disturbances into the station coordinate time series, decreasing the overall station performance. The tracking, analysis and bookkeeping of those effects may improve significantly the derived kinematic parameters. The basic task of the SP is to identify bad periods and jumps in the time series and try to relate them with real physical changes at the station reported by the station manager in a respective log file. In a follow on step the bad periods are eliminated, the jumps/offsets are computed then corrected and a homogenous, problem-free time series are produced. The basic rule is that only these effects are considered, which correspond to real, reported physical changes at the site. The collected information is summarized in a Bernese format station problem file (STACRUX.EPN). The first version of this file will be freely available in the Spring of 2002.

The periodical effects and the different noise components (white and colored noise) are also studied in detail *[Caporali, (2001)]* in order to improve the quality of the estimated kinematic parameters.

At the EPNCB website (www.epncb.oma.be/series.html) the so-called *standard* (see Fig.3) and the *improved* time series are displayed for each station. The standard series intend to show the station performance as it is, while the purpose of the improved series is the estimation of the 'best' kinematic parameters and the visualization of the corrected, filtered time series. More detailed report on this activity is given in *[Kenyeres, Bruyninx (2001)]*.

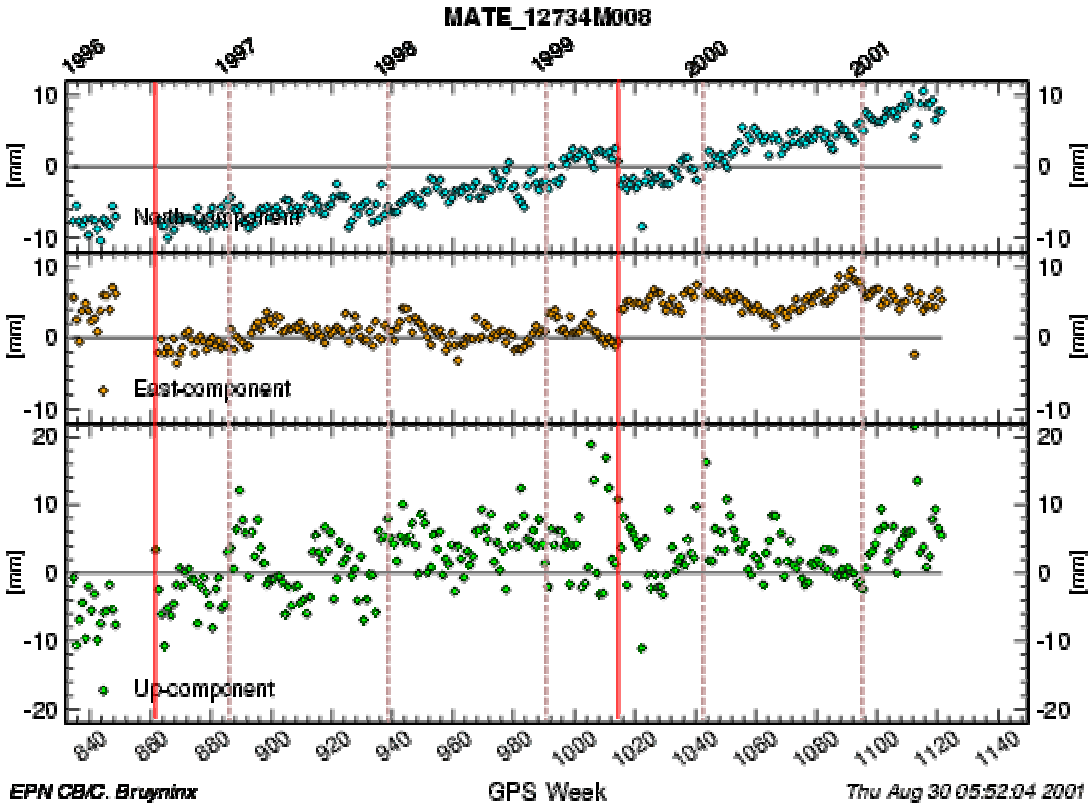

Figure 3. The standard time series of MATE station. The solid lines indicate the changes in the equipment configuration. The tilt in the time series has no strict relation to the intraplate velocity of the station.

c./ Site configuration monitoring

The EPN sites are mostly designed to serve as geodetic reference stations, hence the site selection and the monumentation does not always meet the strict stability requirements of the geokinematic networks. The better understanding of the derived velocity pattern and the ability to separate the non-tectonic signal from the site velocity solution requires detailed information on site quality, monumentation stability and possible environmental impacts (multipath, tectonic activity, …etc.). The simplest way to collect such information is to include it in the site logs. Taking advantage of the opportunity that the IGS recently issued the new GNNS site logs we successfully proposed to include several new items into the log, which help the qualification of permanent sites. It is expected that the new site log will become effective very soon. Taking the site stability into account, and based on the collected quality information, all EPN stations will be associated with an 'SP Quality Code'. This work is not yet started, methodological investigations are foreseen. The site quality monitoring is strongly supported by the work done at the EPN CB, where azimuth/elevation graphs and the number of observed satellites are regularly created and displayed *[Takács, B.- Bruyninx, C. (2001)]*. These graphs should be very useful, when the station performance changes rapidly, without any notice in the log files. The experiences on site quality monitoring collected at epoch-type networks [*Lévai et al, (1998)]* could be also significant.

Future activities

The activities of the SP are separated into different working phases, which may have some temporal overlapping. The first and primary task is to determine the offsets and bad periods for each station backward to the site installation epoch. This information is collected into a station problem file (the deadline for this work is mid-2002) and then this database ought to be maintained and regularly updated.

The 2nd work phase is related to the detailed mathematical analysis of the time series concerning the noise content (white/colored noise) and the presence of periodic signals in the weekly and daily solutions. This work already started *[Caporali, (2001)]* and will gain importance in the future.

One of the future products will be a regularly updated velocity solution for the EPN sites. The first solution will be available after the completion of the station problem file. In this direction further investigations are planned, different softwares, multi-year combination methods will be investigated and tested.

References

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