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EPN Analysis Update

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Abstract

Updated information about the analysis of the EUREF GPS Permanent Network (EPN) will be presented. The report covers the field of the sub-network analysis by the Local Analysis Centres (LACs) as well as the generation of the EPN combined solution. The EPN Analysis Centre Workshop in Graz, September 2004 concluded a number of recommendations that sketch the activities within the EPN analysis for the next two years. A study of outstanding stations of a single LAC as well as a comparison of various EPN time series will be shown. The majority of planned changes in the analysis strategy require new options of the analysis software, which will become available with the version 5 of the Bernese GPS Software.

1 Introduction

It is a continuously task of the LACs to analyse their corresponding sub-network every week since the beginning of the EPN operation in 1996. "EUREF must provide the best possible unique and homogeneous reference system and respective realization" according to its terms of reference. This objective requests to check the equipment of GPS permanent stations and the analysis software and models against state-of-the-art scientific developments. The LAC workshops, which are usually held at every 2 years, are an important contribution to guarantee the usage of modern processing strategies. The inspection of the meanwhile 8 years solution series of the EPN may discover lacks of the analysis strategy, e.g., show not modelled effects. The EPN not only provides the realization of a geodetic reference system for Europe, but also participates in projects that focus on other topics, but are related to reference systems, e.g., the IGS TIGA pilot project. GPS permanent stations near tide gauges help to separate lea level change and vertical land movement. EUREF submits an EPN sub-network solution to the TIGA data centre for every week. The following paragraphs show the recent progress in the EPN analysis.

2 EPN Local Analysis Centre Workshop 2003

The 4th EPN LAC workshop was hold at the Space Research Institute, Department Satellite Geodesy, Austrian Academy of Sciences in Graz from September 18 to 19, 2003. 28 participants from 16 nations verify the widely acceptance of the workshop, and 14 of the 16 LACs had been represented. The objective of the workshop was to review the work of the last 2 years, to discuss about participation in current and future projects, to improve the analysis strategy, and to investigate the future direction of the EPN. Thus there was the goal to develop a roadmap for the next 2 years. The 4 sessions of the workshop covered the topics (1) LACs reports, (2) EPN special projects reports, (3) processing strategies, and (4) discussion. The results of the discussion have been compiled into the minutes that are available at the EPN

central bureau together with all workshop contributions. Most of the planned actions require the new version 5 of the Bernese GPS Software as could be seen in table 1.

Recommendation 1: To fix the datum of the weekly EPN solutions, as well as the individual LAC solutions, the minimal constraint approach is better than the fixed-station approach. Using the present version of Bernese, it is not possible to apply this minimal constraint approach and to write the results into a SINEX file. This topic will be re-discussed when the next Bernese version will be released.
Recommendation 2: In order to evaluate the use of daily SINEX submission by the LACs, H. Habrich will invite the LACs to participate in a test campaign (~8 weeks). The final decision on the daily SINEX submission is delayed until the results of the test campaign are available and the datum definition of the sub-networks has improved.
Recommendation 3: Who is using the weekly ETRS89 solutions? Should we recommend a pre-transformation from ITRFxx to ITRF2000 before the transformation to ETRS89 to prevent the rotation in the ETRS89 which becomes visible since the usage of ITRF2000? Discuss these topics at the next meeting of the EUREF Technical Working Group.
Recommendation 4: Contact the IERS Special Bureau for the Atmosphere and inform them about EUREFs interest for the modelling of the atmospheric loading. Other methods to improve the height component can only be implemented when using the Bernese V5.0.
Recommendation 5: Absolute receiver and satellite antenna PCVs will improve the EPN solutions. However, their implementation should be coordinated with the IGS and will therefore at least be postponed until the next IGS workshop in Berne, March 2004.
Recommendation 6: H. Habrich will invite the LACs to participate to some test computations adding GLONASS data to their sub-network solution.
Recommendation 7 - Processing Options - **Recommendation 7.1:** Should we allow solving for troposphere gradients? It is to soon now to know what to do. Better is to wait and gather experience with the new Bernese software version. **Recommendation 7.2:** Are there any alternatives to the weighting scheme that is presently used to create the EPN Combined Solution? H. Habrich will look into how the IGS is doing the waiting and investigate whether it can be used for the EPN combination. **Recommendation 7.3:** Should we introduce satellite dependent weights, e.g., the accuracy codes as given in the IGS orbits? Presently, the use of satellite dependent weights needs further testing and should be re-discussed in the future. **Recommendation 7.4:** Should we reprocess the EPN? Although a complete reprocessing of the EPN would improve the overall consistency of the time series, it is recommended to wait for a final decision on the absolute PCVs and the new Bernese V5.0, which will include new processing options that will improve the overall quality of the computations. **Recommendation 7.5:** Should we use the radom-dependent receiver antenna calibration values that IGS issues into the EPN processing (20 character code not fully supported by Bernese Version 4.2)? The EPN LACs that use software other than Bernese should test the radom-dependent calibration values and inform the Analysis Coordinator about this, so that he can test for inconsistencies between the different solutions. **Recommendation 7.6:** The proposal for a new LAC in Bucharest at FGB (Faculty of Geodesy Bucharest) was generally accepted. The plenum of the Workshop became convinced to favour the distribution of the EPN analysis to many European nations against the scientific aspect of a common solution. FGB will contact the EPN-CB if it is prepared to start with the analysis. After that, a sub-network will be designed.

Table 1: Minutes of the 4th LAC Analysis Centre Workshop 2003, Graz

3 Comparison of Coordinate Time Series and Datum

There exist various time series of coordinates of EPN stations. The EPN Central Bureau holds 4 precisely explained time series. More time series are available at, e.g., SOPAC (http://sopac.ucsd.edu/) and JPL (http://sideshow.jpl.nasa.gov/mbh/series.html). The comparison between time series needs careful interpretations. Some series show inconsistencies that are caused by the introduction of a new ITRF realization and a certain number of stations show annual signals that are not yet explained and accounted for. It has to be pointed out, that the reference stations of the network per definition have no annual signal but are strictly linear. EPN stations that show an annual signal must not be used as reference as a consequence of this definition.

Figure 1 shows the RMS error of two series of 7 parameter Helmert transformations. Weekly ITRF coordinates of EPN stations were shifted to the specified GPS weeks by applying ITRF Velocities. Such weekly coordinates were compared to the weekly combined EPN solution that is aligned to ITRF by a selected number of reference stations. The upper curve of figure 1 shows the RMS of a Helmert transformation between the two solutions. Such RMS significantly improved after the introduction of ITRF2000 in the EPN weekly solutions in GPS week 1143. Since that week the RMS is continuously growing. The ITRF coordinates suffer from stations with poorly determined ITRF velocities. Velocity errors as more degrade the ITRF coordinates as more the epoch is gone from the reference epoch of the ITRF realization. This velocity error does not affect the weekly EPN solutions. The resulting inconsistency between the two solutions explains the increasing RMS error. It will be “reset” once again after the introduction of a new ITRF realisation.

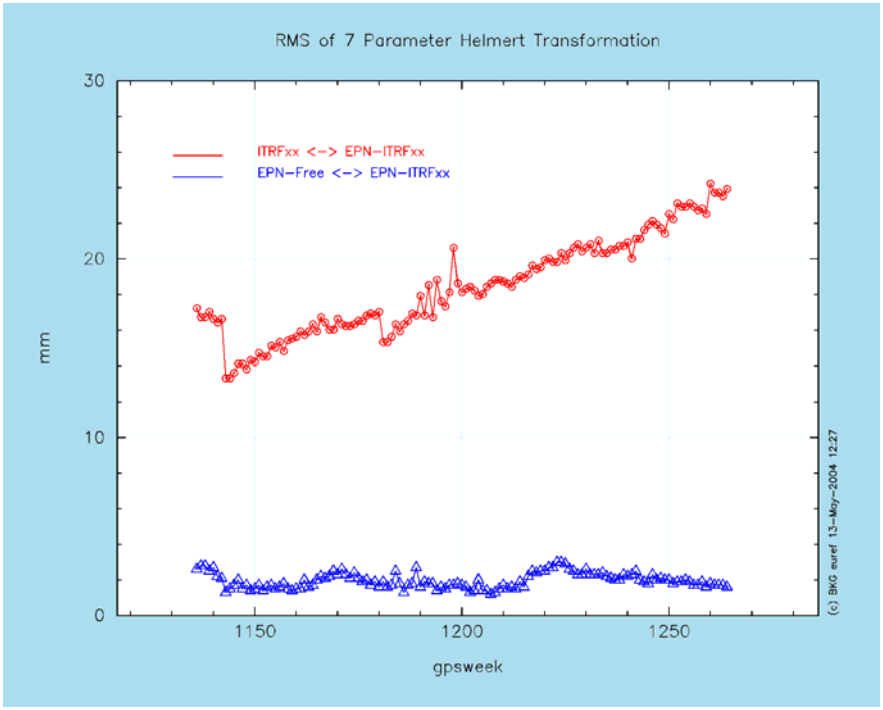

Figure 1: Time Series of Helmert Transformation

4 Investigation of Outstanding Stations

A certain group of stations of the DEO (Delft Institute for Earth-Oriented Space Research, Delft, The Netherlands) sub-network shows significant discrepancy in the comparison to the EPN combined solution on regularly basis. These phenomena could not yet be explained. DEO uses GIPSY compared to the majority of the LACs that use Bernese GPS Software. It

raises the question, whether there is a dependence on the analysis software. This may be investigated by the analysis of the data of the concerned stations with a third type of software. Lina Ferraro from ASI (Agenzia Spaziale Italiana, The Centro di Geodesia Spaziale, Matera, Italy) offered to analyse the particular stations with MicroCosm software for comparison. The solutions of the period from week 1236 to 1241 from ASI do mainly not exceed the threshold of 5 resp. 10 mm for position resp. height components, when they are compared to the EPN combined solution. The inconsistency in the DEO solution could not be confirmed by the ASI results. The analysis of the corresponding stations with MicroCosm Software is in good agreement with the Bernese Software solutions. I express many thanks to Lina Ferraro for the test computation and her remarks to the results. The inconsistencies for some stations in the DEO sub-network remain unexplained. We suspect „different causes behind the common problem“.

5 Other Activities

The EPN contributes to the GPS Tide Gauge Benchmark Monitoring - Pilot Project (TIGA-PP) of the IGS and submits a sub-network solution of the EPN for every week since October 2002. A backwards extraction of the sub-network up to week 1021 (August 1999) was processed in May 2004 and transferred to the TIGA data centre. The Sub-network consists of currently 18 stations, 7 of it are reference stations for the connection to ITRF (see Figure 2). The filename ETGwwww7.SNX is used to store the results in SINEX format.

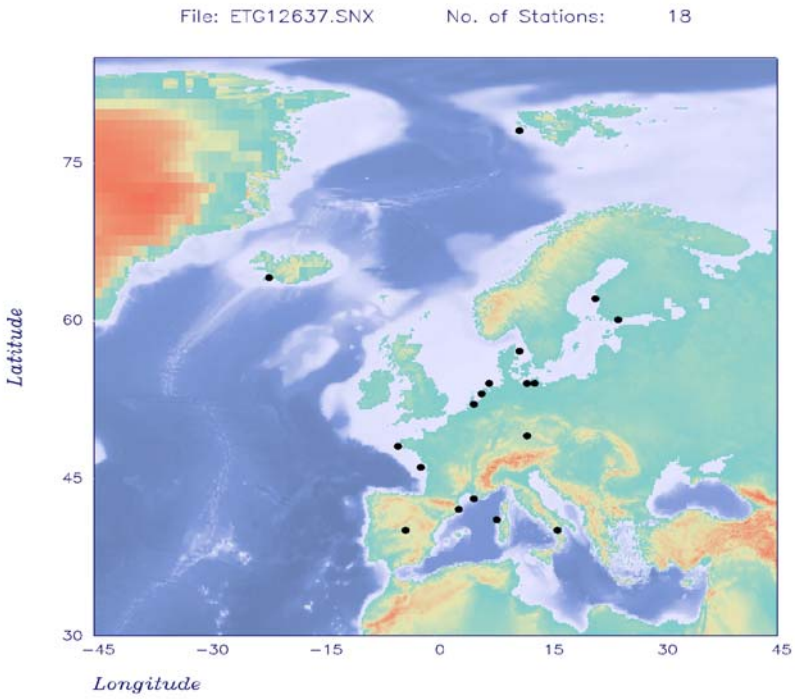

Figure 2: EPN Contribution to TIGA Pilot Project

A new structure of the BKG Data Centre Server has been developed in 2003 and is now in the test phase. The concept had been presented at the IGS Workshop 2004 in Berne. The new server is more robust and comfortable for users and for the day-to-day administration. Figure 3 shows an example of the Internet connectivity monitoring between BKG and ROB, as it is now available.

6 Summary

The operation and analysis of the EPN is a permanent task and therefore it requires much effort from all participants in the project for 365 day each year. The minutes of the 4th LAC workshop in Graz, 2003 demonstrate the ongoing initiative to improve the EPN solutions. The contribution of the EPN to the TIGA-PP is an example for the acceptance of EUREF by other

user communities. It has to be mentioned here, that the EUREF Technical Working Group is also in contact with the European Sea Level Service (ESEAS) to elaborate cooperation between the two projects.

References:

EPN Central Bureau (2003): *Minutes of EUREF Analysis Workshop, Graz, September 18-19, 2003*, http://www.epncb.oma.be

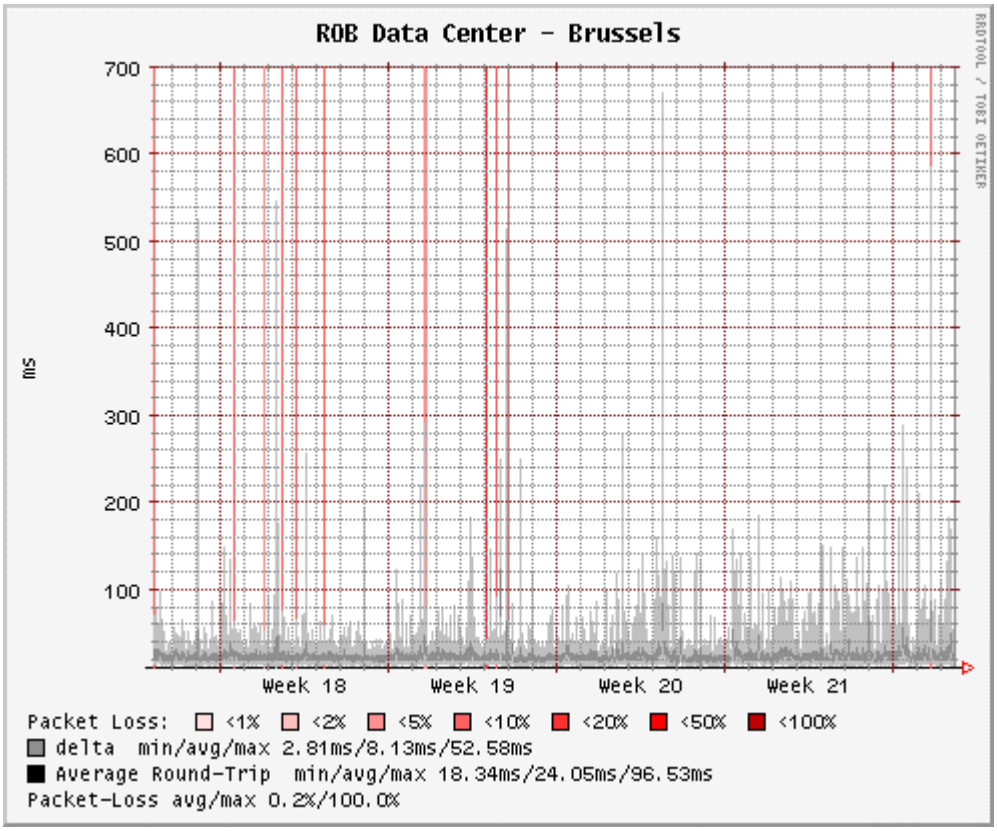

Figure 3: Internet Connectivity Statistics BKG – ROB