The EUREF RNAAC: 1999 Bi-Annual Report

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1 Introduction

Since the beginning of 1996, the EUREF network has evolved from about 30 permanent tracking sites and 4 analysis centers to close to 100 stations and twelve analysis centers delivering weekly solutions.
Although the primary purpose of establishing the Permanent EUREF Network was the maintenance of the ETRS89 (the European Terrestrial Reference System), its data, structure and results have become valuable for a wide variety of scientific investigations. This was formally endorsed by the EUREF sub-commission at its ninth Symposium in Prague (Czech Republic) in June 1999.

2 Network Status and Developments

Tracking network
At the end of 1999, nearly 100 stations were listed as part of the EUREF network (Figure 1), half of them belonging also to the IGS. In 1998, 12 new stations joined the network ; in 1999, 21 new stations registered including a lot of new stations in the Eastern, less densified, part of Europe.
Data from most of the EUREF stations are available within a 24-hour delay. Hourly data uploads have been initiated in October 1998 ; one third of the EUREF stations (32) presently provide hourly data.

Since mid 1999, tracking stations not fulfilling the IGS/EUREF standards for more than three months receive the label *"inactive"* with as direct consequence that EUREF stops its engagement to monitor and process the station data and auxiliary information. Four permanent tracking stations fall presently within this category.

Responding to a general request, EUREF accepts since June 1998 stations from outside Europe (North Africa, Middle-East) into its the network. These stations are known as "*Associated EUREF stations"* and their inclusion in the EUREF network should allow to better assess the motion of the European plate with respect to the neighboring continental plates. Examples of *Associated EUREF stations* are Yerevan (Armenia) and Mitzpe Ramon (Israel).

Data Centers
During the years 1998 and 1999, all EUREF local data centers switched to the use of the Hatanaka compression. Since October 1998, a few of these data centers started to make available hourly data.
In addition to this, all data centers started to make available standard data holding files. These files are retrieved by the EUREF CB and merged together in order to have a complete overview of the data availability within the EUREF network.

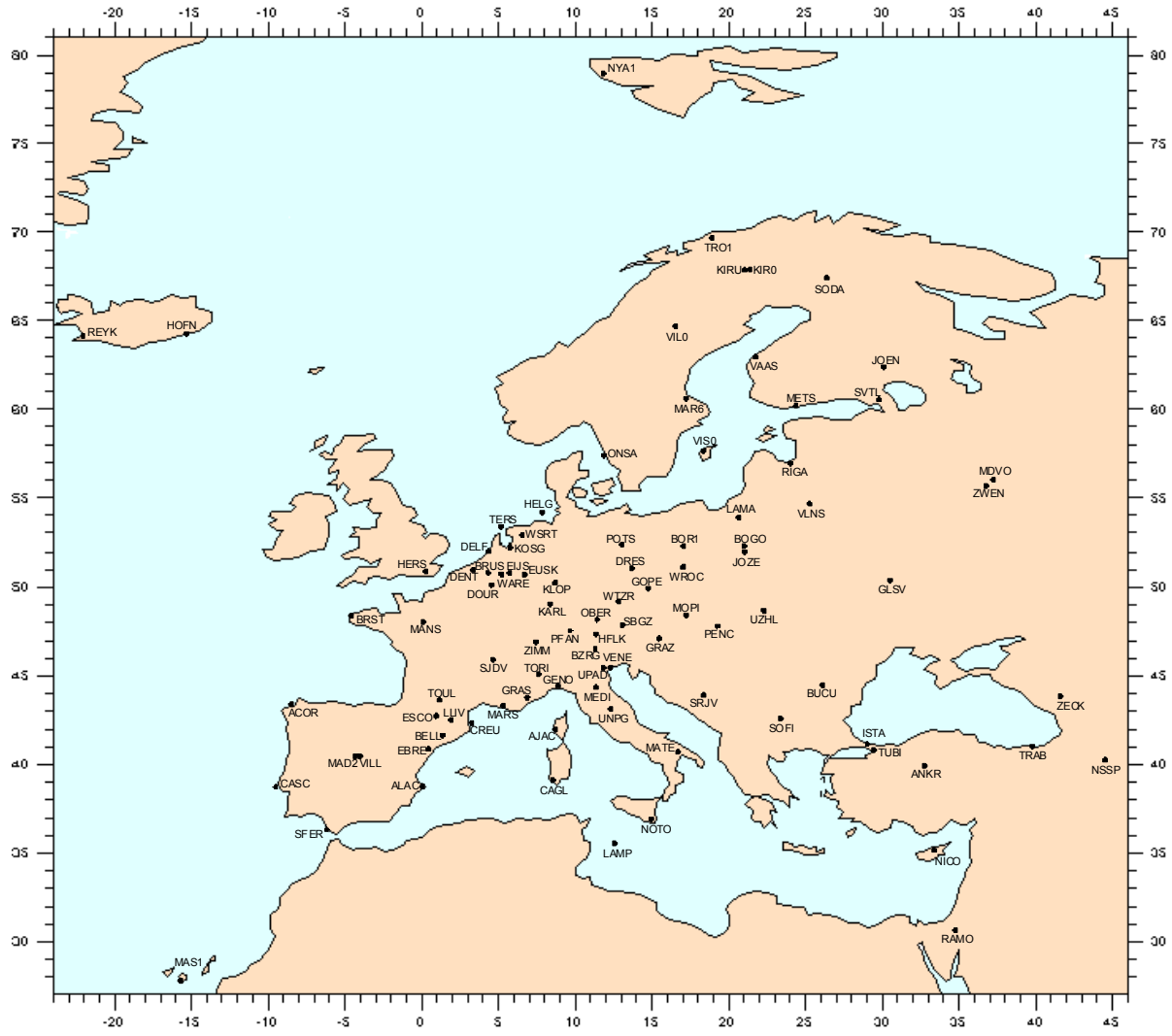

Figure 1 . Network of EUREF tracking stations, as of January 1, 2000

Data analysis

The EUREF data analysis is based on the distributed processing approach where 12 Local Analysis Centers (AC) each processes a sub-network of the EUREF network. Two of these analysis centers recently started to submit solutions to EUREF:

- ✓ Institut Géographique National (Marne-la-Vallée, France), submitting solutions since November 1998
- ✓ University of Padova (Padova, Italy), submitting solutions since December 1998

Until July 25 1999, the individual sub-network solutions were combined into one unique EUREF solution by the CODE analysis center. From July 1999, after a six month transition period, the Bundesamt für Karthographie und Geodäsie (BKG, in Frankfurt, Germany) took over this responsibility and became the new EUREF combination center.

3 Activities of the EUREF Central Bureau

The EUREF Central Bureau, managed by the EUREF network coordinator, has been actively working towards a near-real time upgrading of its ftp-site and web-pages which contain all fundamental information for the EUREF network. As a result, in December 1998, a completely re-managed EUREF web-site (http://homepage.oma.be/euref/) including clickable maps, reviewed guidelines for the network components, etc… was presented to the EUREF community. As part of this effort, individual site information pages have been created. In addition to the site description logs, these pages also contain additional information about the availability of e.g. meteorological data, site pictures, collocation with tide gauges,.. . The intention is to

prepare EUREF for multi-disciplinary applications and foster the integrated monitoring of the environmental change.

The Central Bureau also organized an EUREF Analysis Centers Workshop: "Towards Multi-disciplinary EUREF products" at Marne la Vallée, France in September 1999. This workshop addressed issues such as the creation of a future troposphere product. One of the outcome of the workshop was a endorsement of the strength of the multi-centers data analysis (at least three analysis centers for each EUREF station) and a formal engagement of the EUREF AC's to extend their sub-networks in order to guarantee this principle. As a result, at the end of 1999, 90 % of the EUREF stations were processed by 3 AC's, 8 % by 4 AC's and 2 % of the stations is only processed by two AC's. Minutes of the workshop are available at the EUREF Web site.

The IGS Central Bureau initiated on April 9 1999 the switch to new receiver and antennae equipment names. The EUREF Central Bureau performed the role of liaison between the IGS and the EUREF tracking stations and coordinated this switch at the EUREF level. The new equipment names became active on May 26, 1999 simultaneously with the IGS. At the analysis level, starting on July 4, all EUREF analysis centers delivered SINEX files using the new naming conventions. The switch at the analysis level was again done simultaneously with the IGS analysis centers avoiding discrepancies at the GNAAC's combination level. Additionally, following IGS recommendations, from July 4 on, the 4-char site identification used for the RINEX files and log files has been adopted as the unique site name accepted in the SINEX files.

4 EUREF Data Processing

The distributed processing at the twelve analysis centers still follows the guidelines published in the 1997 IGS Technical Report (Bruyninx et al., 1997). For the combination step changes were made in the generation of the solution fixed in the ITRF. Due to the increased number of sites and the distribution of sites amongst the different analysis centers the following anchor sites in the ITRF96 and ITRF97 were used respectively:

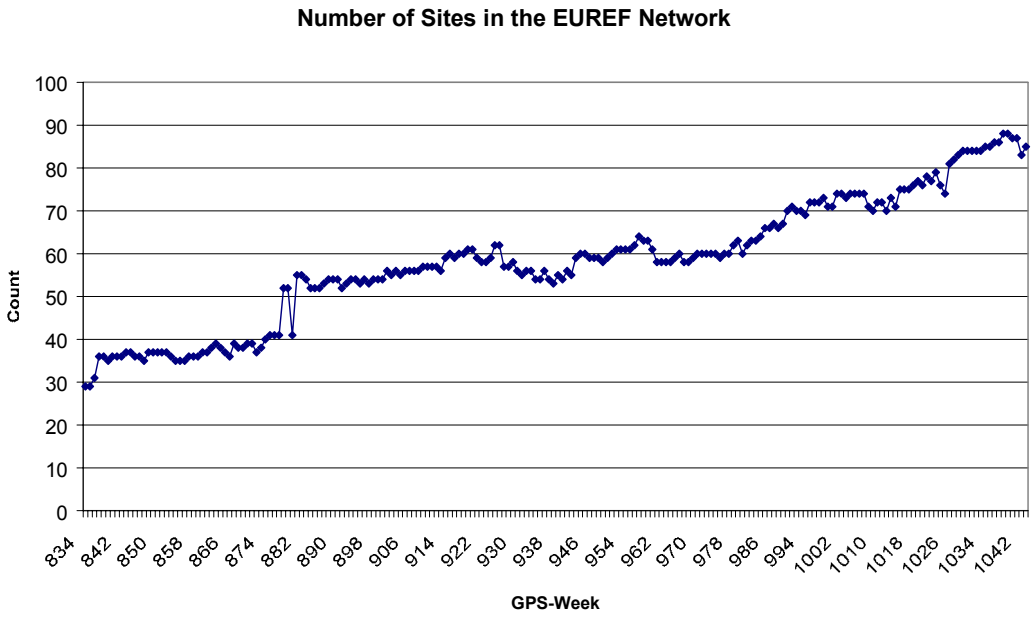

Fig.2. Number of active sites used in the weekly EUREF combination.

- For the realization of the ITRF96 reference frame the following sites are used from GPS week 0947 - 0981:
  BOR1, GRAZ, KOSG, MATE, ONSA, POTS, REYK, WTZR, ZIMM, ZWEN, VILL
  From GPS week 0982 – 1020:
  BOR1, GRAZ, KOSG, MATE, ONSA, POTS, REYK, WTZR, ZIMM, ZWEN, VILL, GRAS

- For the realization of the ITRF97 reference frame the following sites are used from GPS week 1021 onwards:
  BOR1, GRAZ, KOSG, MATE, ONSA, POTS, REYK, WTZR, ZWEN, VILL, GRAS
  NYA1, TRO1, THU1.

The quality of the combined solution is shown by the combination of the loosely constrained weekly solutions into a multi year combined solution. Fig. 2 shows the number of sites active in the EUREF network from GPS week 843 to 1043. The distribution of the rms values of the residuals of weekly solutions versus the combination solution for these sites is shown in Fig. 3. The average of the residual's rms is 1.60, 1.68 and 4.86 mm for the North, East and Up components respectively.

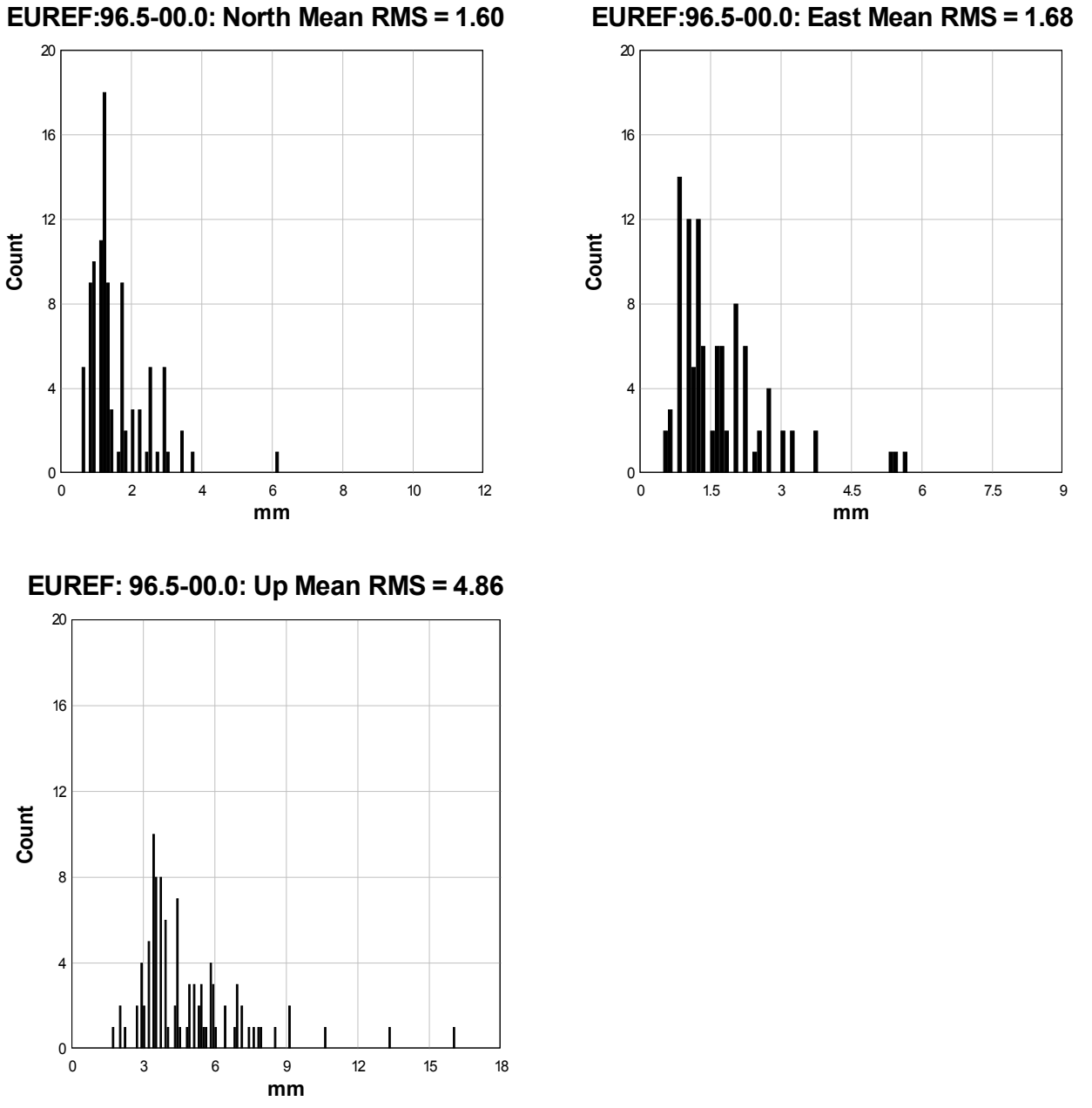

Fig. 3 Histogram of rms values of site residuals of weekly EUREF combinations versus multi year solution.

The histograms in Fig. 3 show a few outliers which result from systematic differences between the three solutions submitted. This indicates sites with problems and possible modelling imperfections which call for further improvement in the standardization and the guidelines, see sect. 6.

5 EUREF Contribution to the ITRF2000

The EUREF - RNAAC computed a multi year combination of the weekly EUREF solutions as regional densification of the ITRF. In order to avoid the problems in the transition from ITRF93 to ITRF94 at GPS week 860 (June 30th, 1996), the weeks 834 to 859 were not used in the combination. Because of the long time series now available and due to the fact that for most of the sites the noise in this leading week is higher as in recent times, this seems to be justified. The combination was based on the SINEX files of the weekly solutions and was computed by use of the program ADDNEQ2 of the Bernese Software Vers.4.3. (Mervart, pers. comm. March 2000). The solution is summarized in tab. 1.

The so-called STACRUX-file containing all information on site changes, antenna changes etc. of EUREF which is available at the Central Bureau was used assure the generation of consistent coordinates and velocities. In addition < 15 outliers of single sites were eliminated. At some sites discontinuities in one of the coordinate components occured which could not be associated to logged changes eccentricities or antennas. These sites are listed in Tab. 2 and for them one velocity but two sets of coordinates for different time periods were estimated. In addition , sites which a recording history shorter than 6 months were constrained to their NUVEL 1A NNR velocities.

Observation-Interval:	Week 0860 – 1042
Time period	June, 30, 1996 – January 1, 2000)
Number of GPS weeks used	183
Number of weeks neglected	26
Program used	ADDNEQ2, Bernese 4.3

Tab. 1 Summary of EUREF contribution to ITRF2000.

Station Name	Start Epoch of Second Coordinate Solution
	YYYY MM DD HH MM SS
ANKR 20805M002	1999 08 15 00 00 00
HERS 13212M007	1999 04 25 00 00 00
PFAN 11005S002	1999 10 31 00 00 00
TRO1 10302M006	1998 12 27 00 00 00
ZIMM 14001M004	1998 11 08 00 00 00

Tab. 2. Sites with offsets in the time series modelled as two independent sets of coordinates.

Number of stations	95
Additional coordinates of identical sites	5
Number of sites with velocity estimation	82
Number of Input NEQ-files	183
Number of Observations:	9583735
Number of Parameters	5835305
Number of Unknowns	600
A posteriori RMS	0.0036 m

Tab.3. Statistics of EUREF contribution to the ITRF2000.

The statistical information on the EUREF processing for the ITRF2000 is given in Tab.3. Two version of the solution are generated, a loosely constrained solution and a solution constrained to the ITRF97 coordinates and velocities of the following core sites: MATE, ONSA, POTS, WTZR, ZWEN. For geophysical investigations and interpretations of site velocities other strategies may be used in future.

For a first assessment of the accuracy of the EUREF contribution the solution was compared to the ITRF2000 contribution of CODE (Springer, pers. comm.). The rms of the differences of the 38 sites in common are .9, 2.7 and 4.9 mm in North, East and Up components at a central epoch. The agreement is excellent and is rather consistent with the internal precision of the weekly solutions.

6 Outlook

The continuous extension of the EUREF network, both through its components as its applications, urges for a reorganization of the coordination tasks. The charter for this reorganization will be set up by the EUREF Technical Working Group and it will focus on a the development of a full service supporting a wide range of applications, such as:

- geodynamics : almost 4 years of EUREF solutions are available now
- sea level monitoring : one out of three EUREF stations is installed near a tide gauge
- meteorology : one out of three EUREF stations is submitting hourly data
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and it will allow the network to flexibly adapt to future demands and applications.

The analysis guidelines, adopted in April 1997 by the EUREF AC's to guarantee the homogeneity of the EUREF solution have aged. New analysis guidelines will be developed and implemented in 2000. This may help in reducing the systematic differences between AC's, e.g. by consistently modelling ocean tidal loading, improving the tropospheric zenith delay estimation (mapping function and elevation cutoff) and more.

One important point which is not sufficiently clarified till now is the use of a consistent set of antenna phase-center calibration tables. A number of antenna types used in the EUREF network is not adequately modelled and included in the IGS tables. There is a urgent need for a generally accepted update of the IGS antenna phase-center correction tables.

7 References

Bruyninx, C., D. Ineichen and T. Springer (1997), "The EUREF RNAAC: 1997 Annual Report ", in International GPS Service for Geodynamics, 1997 Annual Report, Jet Propulsion Laboratory, Pasadena, California

Acknowledgements

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