The European Reference System Coming of Age

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Paper submitted to the IUGG General Assembly, Birmingham / UK, July 1999

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Abstract

More than ten years ago, the advantages of the GPS technology were recognised and a first GPS campaign covering the western part of Europe was organised in order to establish a uniform European Reference Frame (EUREF). Through successive GPS campaigns, the network has been extended towards eastern parts of Europe and various countries have undertaken densification campaigns. The international co-operation within Europe has resulted in the establishment of a high accuracy, three dimensional geodetic network with links to global and national reference systems.

Strategies and guidelines have been developed for network densification, observation procedures, data flow and data analysis. This has resulted in today's permanent GPS network comprising in excess of more than 75 stations, a data handling service and supported by 12 analysis centers. The results show an accurate and consistent network(+/-3mm in the horizontal component, +/-6mm in the height component).

Since 1995, emphasis has been placed on the height component, resulting in an extended and improved adjustment of the United European Levelling Network (UELN) and the establishment of the European Vertical GPS Reference Network (EUVN). Today, the EUREF Network contributes towards multi-disciplinary activities such as the estimation of meteorological parameters and links to tide gauges.

1. General Remarks

At the end of the 80th the requirement for the provision of geoinformation data on a uniform geodetic reference system grow tremendously due to the availability of GPS and its applications prospected in many areas of surveying, navigation, transportation, logistics and much more. As e.g. uniform maps all over Europe were requested from the car industry for navigation or the EUROCONTROL asked for precise positions at airports, the survey agency in Europe came under pressure to establish a uniform reference frame. At that time, the uniform network over Europe was the European Datum ED50 resp. ED87, derived by the IAG Commission RETrig, as a result of the combination and readjustment of the national triangulation networks, which never fulfilled the new requirements. Also the World Geodetic System 1984 (WGS 84) with its realisation via GPS of only a few meters did not fulfil the expectations.

Regarding the future needs of precise basic reference networks for both practical and scientific applications and for the investigation of geokinematical and geodynamical aspects the IAG at its General Assembly in August 1987 formed the new subcommission EUREF, which should continue the work of RETrig, employing new space techniques for the implementation of a European Reference Frame. One month later the Comité Européen des Responsables de la Cartographie Officielle (CERCO) was faced with similar problem - more from the view of digital maps and practical applications - established the CERCO Working group VIII (WG VIII), which should focus on the applications of GPS in the national land survey agencies. (H. Seeger became the president of the CERCO WG VIII). In order to avoid the duplication of work a joint meeting of both groups was held to analyse the requirements and to set up the steps necessary to realize the European Reference Frame (EUREF). A steering committee was established. Members were Augath/Germany, Bordley/UK, Boucher/F, Engen/N, Gurtner/CH, Seeger/Germany and Sigl/Germany.

Some investigations (e.g. EUNAV) using GPS, which at that time was in the test phase with only seven satellites, were conducted to study its application for the realisation of EUREF. A timeslot of only a few hours per day with more than 4 satellite was available. The receivers still were in a development phase (dual frequency, Code-, phase measurements only few channels etc.). GPS observations were carried out in collocation with SLR (Satellite Laser Ranging) and VLBI stations, in order to compare and estimate the accuracy. The maximum deviation of only 3cm between GPS and SLR/VLBI solutions encouraged to commence the Project EUREF.

It has to be stated, that in the beginning not all 24 GPS-satellites have been in orbit, only observation windows of several hours per day with 4 and more satellites in view have been available. The completion of the GPS improved of course the observation strategies and the accuracy in the positioning. The early EUREF GPS campaigns achieved less accuracy than the campaign observed since 1992.

While in the first years the EUREF activities are based on GPS campaigns of several days of observation, nowadays a permanent GPS network has been set up covering the European area with more than 80 sites. Data links and analysis procedures have been established for the daily determination of the positions, in order to monitor changes with highest accuracy. Guidelines for the establishment and operation of the observing stations and strategies for the data transmissions and reductions have been set up, which are in accordance with the IGS (International GPS Service).

Dependant on the kind of observation (obtained during campaigns before 1992, campaigns after 1992 or as a permanent sites) three classes of accuracy were defined:

- Class A: 1cm accuracy for each component of the three dimensional position in ETRS (1sigma level) independent of the epoch, guaranteed by permanent GPS observations.

- Class B: 1cm accuracy, but guaranteed only at a specific epoch (case in active zones where space geodetic estimates of the velocity are not sufficient accurate), obtained by GPS campaigns since 1993.

- Class C: 5cm accuracy, obtained in the first GPS campaigns from 1989 to 1992.

Today EUREF bodies are

- the IAG subcommission for Europe (EUREF) (chaired by Erich Gubler), which yearly carried out the EUREF Symposium.

- the EUREF Technical Working Group (Chaired by Claude Boucher) which meet twice a year to review the campaigns and released the analysis results under the flag of EUREF.

The EUREF-TWG has set up Working groups focusing on special topics such as height related problems

- the EUVN Working group (chaired by Wolfgang Schlueter), for the establishment of the European Vertical GPS Network, and

- the UELN95 Working group (chaired by Wolfgang Augath) for the refinement of the leveling networks aiming in a dynamical height system.

All the EUREF activities are summarised at the yearly Symposia. Proceedings were published [1][2][3][4][5][6][7][8].

Moreover most of the results are available through the WWW or ftp:

- http://igscb.jpl.nasa.gov
- http://hpiers.obspm.fr
- ftp://igs.ifag.de/pub/IFG/EURO
- ftp:/ftpserver.oma.be/pub/astro/euref
- http://gibs.leipzig.ifag.de
- http://www.oma.be/KSB-ORB/EUREF/
- http://lareg.ensg.ign.fr

2. Concept, Objectives and Relation to ETRS and ITRS

In 1987 the IAG at it General Assembly in Vancouver and the CERCO at its Plenary Assembly in Athens decided independently to develop a GPS based new European Geodetic Reference Frame which fulfil the following requirements:

1. representing a geocentric reference frame for any precise geodetic-geodynamic projects on the European plate.

2. being a precise reference very near to the WGS84 to be used for geodesy as well as for all sorts of navigation in the area of Europe

3. being a continent wide modern reference for multinational Digital Cartographic Data sets, which may not be based any longer on a very large amount of quite different national datums all over Europe.

ED50 rep. ED 87 did not fulfil the requirements especially concerning the overall accuracy and the three dimensional global position and orientation. The WGS 84 on the other hand could not guarantee the required very high precision as – at least at that time- it was mainly derived from Doppler observations.

As in the late eighties the IERS combined SLR/VLBI solutions (ITRF) were by fare the best global realization of a geodetic reference system, the IAG Subcommission EUREF and the CERCO WG VIII agreed to base the European Reference System on the ITRF and to select the about 35 European SLR and VLBI-sites being part of the ITRF-solution computed for the epoch 1989.0 as the basic set of geocentric coordinates defining the ETRF89 (European Terrestrial Reference Frame) as the first realisation of the European Reference System ETRS. Doing so at 1989.0 ETRF is a subset of the global solution ITRF89.

Due to plate tectonics the coordinates of the European subset of stations slowly change in the order of about 2cm/year. Therefore it was decided that ETRS89 should rotate with the stable part of Europe, so that the station to station relations are kept fixed. Of course, from such a decision it results that the relationship to positions defined in another reference system may slightly change. Transformation parameters for the conversion of ITRF to ITRF89 resp. ETRF89 are derived on a regular basis. As consequence the transformation parameters to be determined between ETRF and WGS84 will slightly change and will have to be regularly modified in periods of about 10 years, after the influence of the rotation of Europe will no longer be neglected.

Investigations showed, that at the beginning ITRF89 resp. ETRF89 agreed with WGS84 within 1-2m. Today WGS84 realisation has been improved, so that the agreement is within a few centimeters. The reference ellipsoid for EUREF is the GRS 80 ellipsoid, which differs only slightly from the WGS84-ellipsoid.

3. EUREF Realisation through Campaigns

3.1 Observation Campaigns

The transformation of national coordinates requires at least three but better 6-8 identical points with coordinates in both reference systems (national reference system and ETRS).

Therefore in October 1988 it was decided to perform a European GPS densification campaign (***EUREF89***) -all campaigns are summarized in figure 1- with the aim to establish EUREF-stations at distances of about 300 to a maximum of 500 km (as soon as possible). The final network consisted of 92 sites which were observed by 2-frequency GPS-receivers in 2 different campaigns:

- phase A: lasting from May 16 to May 21, 1989 with 62 sites and
- phase B: covering the period from May 23 to May 28, 1989 with 55 sites.

Among them were 21 SLR- and four VLBI-sites. The subdivision into two phases turned out to be necessary as in spring 1989 only 69 2-frequency GPS-receivers were available in Western Europe. While the precision of the SLR/VLBI-ETRF-coordinates was at that time 13-23 mm per component, the precision of the additional GPS-sites turned out to be around 30-40 mm in the horizontal components and about 50-60 mm in the vertical (the formal errors were with 5 exceptions smaller than 1 cm in all components).

The EUREF Subcommission, recognizing that the coordinates of the stations will be subject to improvement, that the existing network would be extended and that improvements and extensions could affect the homogeneity of EUREF 89, has decided in 1992 that new campaigns to fulfil EUREF standards must include observations of a sufficient number of primary stations (SLR, VLBI) and other neighbouring EUREF sites. The Technical Working Group (EUREF-TWG) has been established to define standards, to monitor the results and to advise the EUREF PLENARY whether the results fulfil EUREF standards and can be endorsed.

In July 1990 the network was extended to the Northwest of Europe (***EUREF-NW***) by including 15 additional stations on different islands including Greenland and Island.

The densification campaign in 1991 covered the *Czech. Republic, Slovakia and Hungary* (***EUREF-East***). It consisted of 11 new points. In 1992 three campaigns, one for *Poland* (***EUREF-Pol***), one for the Baltic States (*Lithuania, Latvia and Estonia*) (***EUREF-Bal***) and one for *Bulgaria* (***EUREF-Bul***) were performed. In Poland 11 new stations were established while in Baltic countries 13 new sites were measured. In Bulgaria 15 stations formed the EUREF network. In 1994 *Croatia and Slovenia* entered to EUREF with 18 stations and *Romania* with 7 stations. In all of these campaigns the involvement and support of IfAG (today: BKG) was substantial, except of the Baltic stations campaign, where the engagement of Scandinavian countries was very helpful.

As the results of the EUREF-NW-Campaign due to ionospheric activities the observations in Iceland from 1991 turned out to be less accurate than for the other parts of Europe. From August 03 to August 13, 1993 a postcampaign (***Iceland 93***) was performed which also included the positioning of additional 115 stations all over Iceland.

From May 30 to June 3, 1994 (four days of 24 hours of observations) *Croatia and Slovenia* were connected to EUREF. The network was connected to the IGS-stations in Wettzell (D), Graz (A) and Matera (I). From 25.09. to 02.10.1995 the area of Slovenia was remeasured as part of a geodynamic campaign including all first order stations. As in 1994 only parts of the Croatian Area could be measured, a new campaign was observed from 29.08. to 12.09.1996 including also all the 63 stations of the Croatian first order network. During this campaign 3 additional EUREF-stations were determined.

From June 19 to June 23, 1995 EUREF was extended into the area of the *Ukraine* (***Ukraina-95***), where 15 stations were observed by Ukrainian/German-teams with Trimble SSE-receivers. The campaign could not be completed, as security forces intervened. The data were confiscated at the border, when the IfAG-teams left the Ukraine. Meanwhile our Ukrainian colleagues are trying to perform their own computations but at present there is no chance to publish the results.

From 12.08. to 17.08.1996 *FYROM (Former Yugoslavia Republic of Macedonia)* (***EUREF FYROM***) was connected to EUREF (6 stations). On the same days Macedonian colleagues measured at additional 18 first order stations of this country and at sites at the airports in Skopje and Ohrid using IfAG-equipment. As further control points further the EUREF-stations Dionysos (Greece), Sofia (Bulgaria) and Ilin Vrh (Croatia) were reobserved. The campaign included 5 sessions of 24 hours each.

Malta was connected to EUREF ***(EUREF-Malta-96)*** from 29.10. to 03.11.1996 (6 stations); control observations were performed at Lampedusa (SLR-site). The campaign included 5 sessions of 24 hours each.

Within the EUREF 98 campaigns GPS measurements were performed in *Albania, Bosnia and Herzegovina and Yugoslavia* between September 4 and 9, 1998 at 29 stations. The selection to become EUREF points is currently under decision.

Covering Europe with the uniform reference network, only a few areas are still missing:

- Belorussia
- Moldavia
- Russia (west of the Ural).

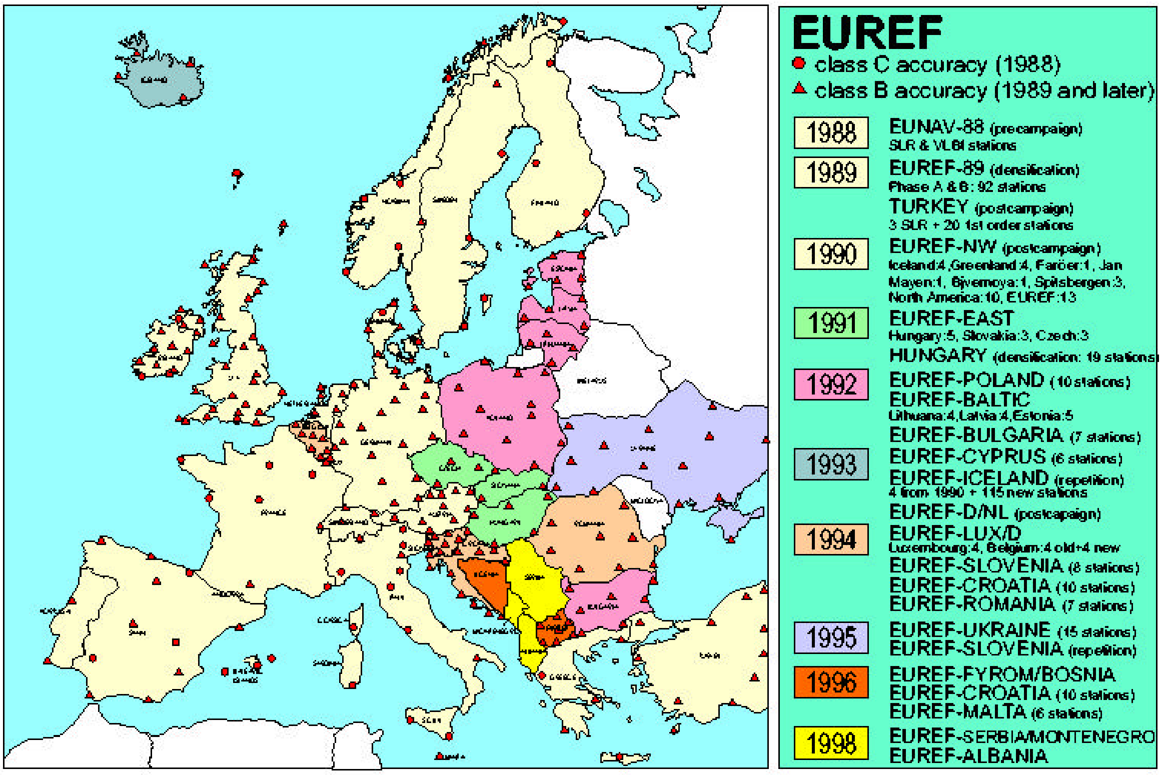
3.2 EUREF-Postcampaigns

After it turned out that the accuracy of the EUREF-1989-Campaign was limited to about 3-4 cm in position, several countries urgently required an improvement as far as the accuracy is concerned. Such activities were performed at least in

- Germany (1993)
- the Netherlands (1993)
- Denmark (1994)
- Belgium (1994)
- Iceland (1993 and 1995)
- UK 1992
- Ireland (1995)
- France (1993)
- Switzerland (1992) and
- Austria.

From 1992 until May 1995 the EUREF Technical Working Group urged every group performing EUREF-Campaigns to refer such networks to the surrounding SLR/VLBI-stations and to neighbouring EUREF-sites. After it turned out to be obvious that this may not be the optimum technique in all those situations where the reference coordinates or their velocities are less accurate than the precision of modern GPS-Campaigns, it was agreed by the EUREF-TWG- and Plenary-Meeting in Helsinki (May 1995), that future EUREF-campaigns should be referred to the surrounding IGS-stations and should also include other neighbouring EUREF-sites to be handled as control points.

Figure 1: EUREF Network from 89 to 99



3.3 Processing strategies and transformation into the ETRS 89

The computation of the coordinates nowadays is performed following the procedures specified by the EUREF Technical Working Group. The following principles are applied:

- use the orbits from the IGS Final Orbit Combination including the associated earth rotation parameters,
- use coordinates for the fixed stations which refer to the reference frame of the orbits (ITRF yz). The coordinates of the fixed stations are then rotated to the observation epoch (19 uv.w) by using velocities given for the ITRF yz (IERS Annual Report 19 yz),
- Computation of 19 uv.w coordinates at the epoch of the observation,
- Transformation and back-rotation of these coordinates into ETRS89 with official parameters.

The conversion into ETRS89 at epoch 1989.0 is performed as follows:

x(SO)=x(S1)+T(S1)+R.x(S1).dt

with

x(SO): coordinates in ETRS89 epoch 1989.0
x(S1): coordinates in ITRF yz at the epoch of observation (19 uv.w)
T(S1): shifts T1, T2, T3, based on a global transformation from ITRFyz to ITRF89
R: rotations (no network rotation) back to epoch 1989.0 due to the motion of the European plate with the motion model NNR-NUVEL

(IERS-Technical Note 13) or with individual velocities
(IERS Annual Report 19 yz) available

dt: time difference of n years (19 uv.w minus 1989.0).

4. EUREF-Permanent GPS-Network

4.1 Relation to IGS

Recognizing the growing number of permanent installations of GPS receivers in Europe, which were collecting continuously GPS tracking data, following the IGS (International GPS Service) regulations, the EUREF subcommission made use of the situation for the maintenance of the EUREF. Werner Gurtner (University of Bern) proposed in 1995 in accordance to IGS the organization of the EUREF permanent GPS network consisting of the following components:

- Permanent GPS Stations
- Operational Centers (OC)
- Local Data Centers (LDC)
- Regional Data Center (RDC)
- Local Analysis Centers (LAC)
- Regional Analysis Center (RAC)
- Network Coordinator

As most of the components still exist, the realisation was more or less a question of the coordination. In October 1995 Carine Bruyninx (Royal Observatory of Belgium) as network coordinator has been appointed. Following the IGS rules, the EUREF permanent GPS network could be regarded as a densification of the global IGS network in the European area. In January 1996 IGS released a "Call for participation as IGS regional networks associate analysis center (RNAAC) for regional station position analyses", to which the EUREF Subcommission responded and expressed the willingness of CODE (Center for Orbit Determination Europe -- a joint cooperation of the University of Bern/CH, Bundesamt für Landestopographie, Wabern/CH, the Institute Geographique National, Paris/F and the Bundesamt für Kartographie und Geodäsie, Frankfurt/D) to act as IGS Regional Associated Analysis Center. CODE delivers weekly free-network solutions for the European region to the IGS global network associate analysis centers. The free-network solutions delivered from CODE is obtained by combining weekly solutions from the Local Analysis Centers (LAC). The IGS has officially accepted the EUREF proposal in May 1996.

The EUREF products are -next to the data of the tracking stations- weekly estimates of the coordinates of the EUREF permanent stations and their covariance information as a combined solution of subnetwork solutions, submitted by EUREF Local Analysis Centers (LAC) . The LAC's process their subnetwork following specific strategies and exchange the results employing the Software Independent Exchange Format (SINEX). To align the EUREF weekly solution with the International Terrestrial Reference Frame (ITRF) a selected set of "reference stations" is fixed to their successive realisations of their ITRS coordinates. In addition, the coordinates are updated monthly using the corresponding ITRF velocity field. Applying guidelines for reference frame fixing, see chapter 3.3, the weekly EUREF solutions, available in ITRFxx, at the epoch of observation can be linked to the ETRS89.

4.2 Network Stations and Operation Centers

The Network is shown in figure 2. More than 80 stations, operating permanently geodetic GPS receivers with antennae mounted on suitable geodetic markers. The stations have to fulfil the EUREF specifications before they obtain the label as a permanent EUREF stations. The criteria are strong in order to ensure the data quality, the timeliness and the reliability of the provision of data, the stability of monumentation and the availability of documentation. Guidelines and data file conventions have been set up which strictly have to be fulfilled. Data provision is required on daily basis via local data centers to the regional data center. Some stations today are able to provide data-files every hour. Operational Centers -mainly identical with the agencies responsible for the stations- perform data validation, conversion of raw data into RINEX (Receiver Independent Exchange Format), data compression, and data upload to a data center through the Internet.

Figure 2: EUREF Permanent GPS Network

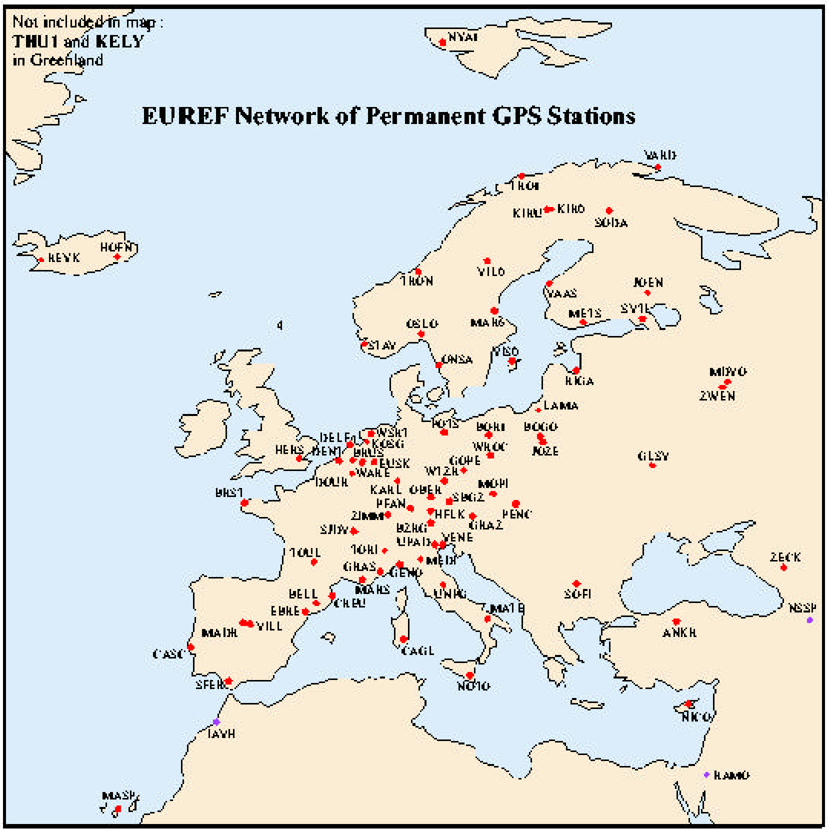
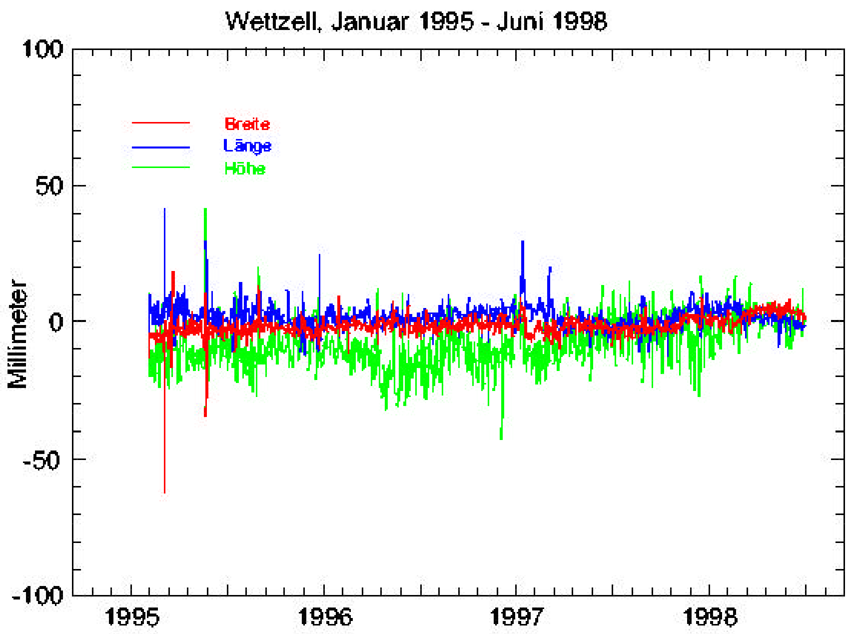


Figure 3: Time Series of WTZR



4.3 Data Centers

Local data centers (LDC) are collecting data of all stations of a local network and distribute the data or provide access to the data. Not all of the local stations need to be EUREF stations. The LDC forwards the data or only a selection of data to a Regional Data Center (RDC), which collects the data from all EUREF stations. While the LDC's in general are identical with the operational centers, only one RDC exists within Europe (table).

Table: Local, Regional and Global Data Centers

		local	regional	global
ASI,	Centro di Geodesia Spaziale/I	x		
BKG,	Bundesamt fuer Kartographie und Geodäsie/D	x	x	
DUT,	University Delft/NL	x		
FGI,	Geodetic Institut Finland/SF	x		
GRAZ	Austrian Space Agency/A	x		
IGNL,	Institut Geographique National/F	x		x
NLS;	Nation. Landsurvey Sweden/S	x		
OSO;	Onsala Space Observatory/S	x		
ROB;	Royal Observatory Belgium/B	x		

4.4 Analysis Centers

Local Analysis Centers processes subnetworks out of the EUREF permanent network following the rules and guidelines as set up by the IGS and supplemented by the EUREF TWG. They submit weekly solutions, which CODE is combining to the EUREF solution. Currently a transition is ongoing concerning the combinations of the solutions. BKG will take over the routine combination process from CODE, after parallel analysis of the data demonstrated identical results and guarantees the same quality and continuation.

Today 12 Loacal Analysis Centers are involved in the data reduction procedure:

ASI	Centro di Geodesia Spaziale - Matera/I
BEK	Bayerische Kommission für die Internationale Erdmessung - München/D
BKG	Bundesamt für Kartographie und Geodäsie - Frankfurt/D
COE	Center for Orbit Determination in Europe - Bern /CH (CODE)
GOP	Geodetic Observatory Pecny - Pecny/CR
IGN	Institut Geographique National - Paris/F
LPT	Bundesamt für Landestopographie - Wabern/CH
NKG	Nordic Geodetic Commission GPS data Analysis Center - Onsala/S
OLG	Institute for Space Research - Graz/A
ROB	Royal Observatory of Belgium - Brusssels/B
UPA	University of Padova - Padova/I
WUT	Warsaw University of Technology - Warsaw/Pl

The subnetworks are organized in such a way, that the data of a permanent EUREF station will be analysed in average by three LOC's in order to avoid unrealistic weighting in the analysis procedure. As example for all stations the time series of WETR is shown in the figure 3.

5. Contribution of EUREF to Height Systems

5.1 The European Height System UELN

************** Help requested by Johannes Ihde **********************************

5.2 The EUVN - European Vertical GPS Network

Within the frame of the IAG-Subcommission for Europe (EUROPE, former EUREF) the activities for the European Vertical GPS-Reference Network (EUVN) have been carried out on the basis of

- Resolution Nr. 2 of the EUREF Symposium in Helsinki, Mai 1995,
- Resolution Nr. 3 of the EUREF Symposium in Ankara, Mai 1996.

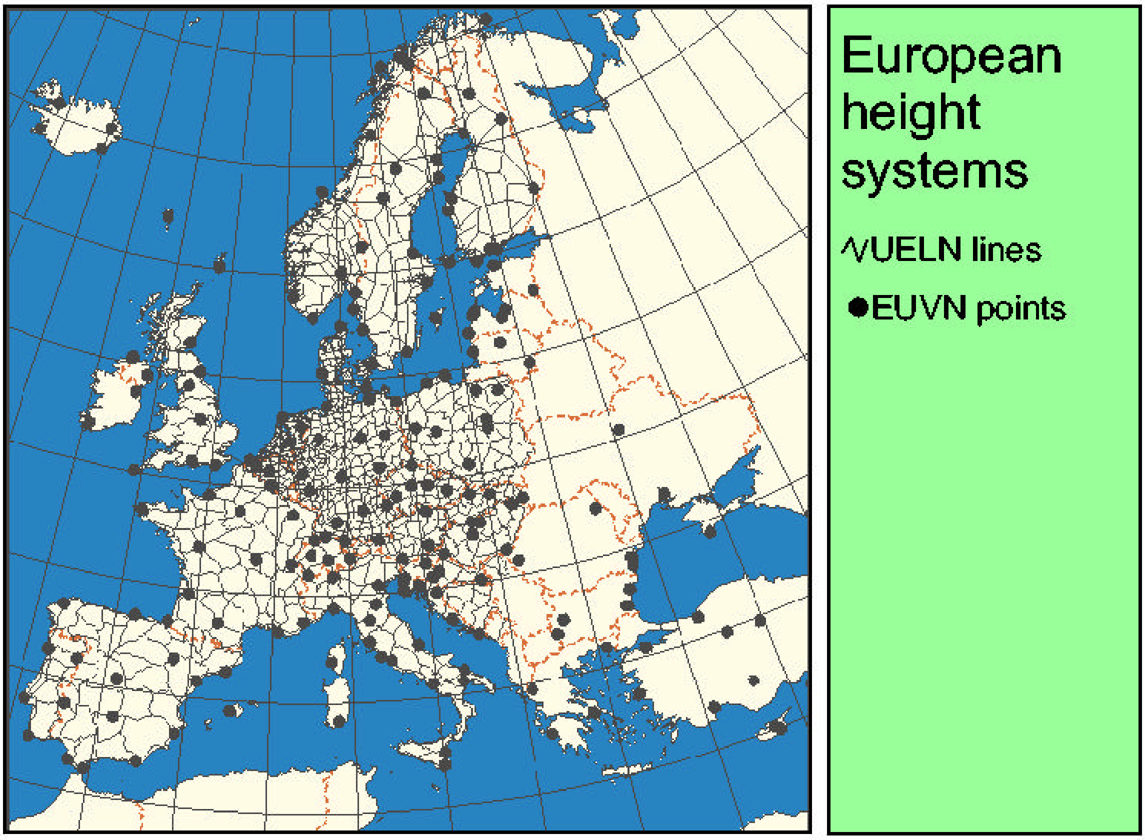
The final objective of the EUVN is to provide a set of coordinates for all EUVN sites consisting of three dimensional coordinates X,Y,Z resp. latitude, longitude, ellipsoidal height and the "physical" height derived through leveling and gravity measurements with respect to the UELN and/or UPLN and/or to the national height system.

The design of the EUVN-network, the organisation and the logistics have been worked out in close cooperation with all the responsible agencies of the participating countries. At first, a letter has been send out to all agencies in Europe to request the interests on the EUVN and the provision of support for the campaign. The agencies have been asked to nominate a national representative as direct contact person to the Working Group.

A workshop with mostly all of the national representatives has been held in Frankfurt, in April 1997, in order to finalize the network design, discuss the objectives and guidelines of the observation campaign and to organise and agree on the collaboration for the campaign.

Circular letters have been send out to distribute the information on the status and on the progress of the EUVN to all agencies who are involved. So far 7 Circular Letters have been released.

Figure 4: EUVN-Network and UELN



5.2.1 The EUVN 97 - campaign

The EUVN 97-GPS-campaign has been carried out in the period from May 21 (18:00UT) to May 29 (6:00UT), 1997. All together 196 sites have been occupied spread over 32 countries. Existing EUREF-sites, Leveling-sites (UELN, UPLN) and tide gauges have been selected as EUVN sites. Some of the sites are identical in the three categories such as EUREF and Leveling sites or EUREF, Leveling and tide gauge sites. The distribution in the different categories is as follows:

EUREF-sites	63
Leveling sites ((UELN,UPLN)	52
Tide Gauges	41
EUREF- and Leveling sites	6
EUREF-sites and Tide Gauges	13
Leveling sites and Tide Gauges	16
EUREF-, Leveling sites and Tide gauges	5

The total number of receivers has been 220,

134	TRIMBLE SSE or SSI,
51	ASHTECH Z12 and
35	TURBO ROGUES.

Some of the receivers have been collocated at identical sites, which provide additional data for the combination of the different receivers. Figure 4 shows the EUVN-Network.

5.2.2 Data Reduction

The preprocessing of the data, which consists of the control of the data and the forms for each sites and of the conversion into the RINEX-format has been carried out by 10 Preprocessing Centers:

Austria:	Institute of Space Research, Graz
Czech Republic:	Research Institute of Geodesy,Topography and Cartography, Prag
Finland:	Geodetic Institute, Helsinki
Germany:	Bundesamt für Kartographie und Geodäsie, AS-Leipzig
Netherlands:	RWS-Survey Department, Delft
Norway:	Statens Kartverk, Hönefoss
Poland:	Space Research Center, Warsaw
Portugal:	Instituto Portugues de Cartografia et Cadastro, Lisboa
Sweden:	Space Observatory, Onsala
Turkey:	General Command of Mapping, Ankara

The RINEX-data are available via the data base of the BKG at Leipzig since September 1997.

The evaluation of the coordinates for all EUVN-sites commenced in October 1997. 9 Analysis Centers (AC's) volunteered to carry out the data reduction. In order to organize the data reduction procedures and to agree on the common processing strategies a first workshop has been held at the BKG in Leipzig in September 1997. The network has been split into 8 subnetworks, each subnetwork was assigned to one AC. One of the 9 AC's (Croatia) took over the evaluation of those observations which have been carried out with collocated receivers. The following agencies volunteered as an AC are:

Austria:	Institute of Space Research, Graz
Belgium:	Observatoire Royal de Belgique, Brussels
Croatia:	Drzavna geodetska uprava, Zagreb
Czech Republic:	Research Institute of Geodesy, Topography and Cartography, Zdiby (Prag)
France:	Institute Geographique National, Paris
Germany:	Bundesamt für Kartographie und Geodäsie, AS-Leipzig,
Poland:	Space Research Center, Warsaw
Sweden:	Space Observatory, Onsala
Turkey:	General Command of Mapping, Ankara

The combination of the subnetworks to the complete EUVN solutions has been taken over by

Germany:	Bundesamt für Kartographie und Geodäsie, AS-Leipzig,
Swiss:	Astronomisches Institut der Universität Bern.

Two more workshops have been necessary in order to exchange the results of the subnetworks to share the experiences, to point out stations which have data problems, to discuss the results and to agree on the final processing procedures. The second Workshop for the AC's held in February, 1998 in Bern/Ch and the third in April 1998 in Wettzell/D. The results have been very promising and the final solution could be presented at the EUREF-Symposium in Ahrweiler.

The collection of the height information with respect to the UELN is still ongoing. For more than 80% of the station the information is available. The tide gauge observations are for most of the tide gauge sites available via the data base of the Permanent Service for Mean Sealevel (PSMSL). For about 60 stations of the 75 tide gauges the data are available. It could be expected that the EUVN project successfully will be closed down in the next time after the presentation of the complete results.

6. Prospects

The EUREF activities have been a strong driving force for the implementation of the GPS-technique since the very beginning in Europe. A lot has to be learned, investigated and developed on the technique itself (observations, analysis, data handling, communications). The objective to establish a uniform reference frame, at first on the basis of campaigns, today on the basis of a permanent network forced all the European countries, involved in EUREF to cooperate, to coordinate their activities and to follow the standards which have been set up by the EUREF-TWG.

EUREF today is the best organized regional network world wide and fulfil the strong geodetic requirements for a reference network on the most accurate level. EUREF is the backbone for national activities e. g. for the establishment of network reference frames and provide the basis for new research such as atmospheric or ionospheric investigations as well as for the monitoring of geodynamical changes (crustal movements, sea level changes).

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