Proposal for the Development of an European Combined Geodetic Network (ECGN)

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Summary

In 1995, EUREF took over the task of the realization and maintenance of European vertical reference systems. The work started with the UELN project and one year later continued with the realization of the European Vertical Reference Network (EUVN). The EUVN is a static integrated network, at all EUVN points three-dimensional coordinates and geopotential numbers are derived. In addition the corresponding normal heights as well as the gravity values are provided. In the tide-gauge stations, the connection to the sea level is realized.

In order to ensure the long-time stability of the terrestrial reference system with an accuracy of 10^{-9} at both the European and global scale, the interaction between the different time dependent influences of the system Earth on the terrestrial reference system and the related observations has to be considered in the evaluation models.

The ECGN is a European network for the integration of time series of spatial/geometric observations (GNSS – GPS/ GLONASS and in the future GALILEO), gravity field related observations and parameters (gravity, tides, ocean tides), and supplementary information (meteorological parameters, surrounding information of the stations e.g. eccentricities and ground water level).

The call for participation is, from the point of view of time, structured in two stages. The first call is directed to the implementation of the ECGN stations following the concept of the project. The ECGN stations have the standard observation techniques GNSS (GPS/GLONASS, GALILEO), gravity (super conducting gravimeter and/or absolute gravimeter), levelling connections to nodal points of UELN/EVRS, meteorological parameters.

Standard for the ECGN stations is a local network for the derivation of eccentricities at a 1 mm accuracy level in all three spatial components. The GNSS part of the observations gathered at the ECGN stations will be an integral part of the EPN (EUREF Permanent Network) and as such will have to fulfill the EPN guidelines.

In parallel to the first call, the ECGN working group will prepare the second call for the analysis and investigations. In the first step, the main action of the ECGN working group will be a pilot study of the combination of the different observations from the available stations, and this to get experiences in the combination of spatial information with gravity field related data. For super conducting gravimeter data, the GGP (Global Geodynamic Project) data centre could be used for data collection. ECGN levelling data will be collected at the UELN/EVRS data center. Local data centers for absolute gravity data and super conducting gravimeter data should be installed in the first stage by the ECGN working group.

Preamble

The principal task of the IAG Subcommission for Europe (EUREF) consists in providing European-wide solutions of a spatial reference system that can be used for both scientific purposes as or the georeferencing of common cartographic data, as urged by the geodetic and cartographic community of Europe. The initial action of EUREF was directed to the spatial reference by GPS. In 1989 EUREF has defined 1989.0 as the reference epoch of the European Terrestrial Reference System (ETRS89) and realized it as frames (ETRF.yy, yy means the year of reference) by densification and maintenance of the ITRF.

In 1995, EUREF took over the task of the realization and maintenance of European vertical reference systems. The work started with the UELN project and continued one year later with the realization of the European Vertical Reference Network (EUVN). The EUVN is an integrated spatial network: at all EUVN points three-dimensional coordinates and geopotential numbers are derived. In addition, the corresponding normal heights, as well as the gravity values are provided. In the tide-gauge stations, the connection to the sea level is realized. Finally, the EUVN represents a geometrical-physical reference frame. In 2002, the EUVN project has been closed successfully and EUREF started the prepare of a new phase (ADAM et al. 2000).

Since decades, there have been several initiatives to connect the reference frames of different geodetic techniques. For the geometrical reference, the real breakthrough was brought by the GPS technique. However, the reliable and accurate connection of this geometrical information with the physical

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(height) reference system is not yet solved. In this sense, the EUVN represents the successful realization of a static geometrical-physical reference frame connection on a continental scale. The integration of all the geometric techniques would be desirable, where gravity must play a key role. In addition, the study of time evolution of the different reference frames and their related parameters (coordinates, gravity values etc.) would improve the knowledge about the connection itself (kinematic approach).

Within EUREF, the European Permanent Network (EPN) is since 1996 in operation, experiences with tide gauges are available, and EUREF started with the adjustment of repeated levellings (EVS 2000; AUGATH et al. 2000). In 2001, EUREF promised their participation of the EPN stations in the IGS GPS Tide Gauge Benchmark Monitoring Pilot Project (TIGA-PP) and the European Sea Level Service (ESEAS).

EUREF already in 1996 proposed, with the Resolution No 4 of the EUREF Symposium in Ankara, to perform absolute gravity measurements. The EUVN project included a subset of gravity values derived by connection measurements between EUVN stations and national gravity networks. The EVS project studied the possibility of using absolute gravity measurements for investigating height variations. But until now the Resolution is not realized.

Major absolute gravity projects within Europe in the last 15 years have been:

- national gravity networks (e.g. German Gravity Base net 1994 (DSGN94), measured with FG5-101 and JILAg-3, Austrian gravity base net measured with JILAG-6, Netherlands gravity base net measured with JILAg-3 and FG5-101, FG5-202);
- geodynamic networks (e.g. to monitor the Fennoscandic uplift (JILAg-5, FG5—102 (NOAA), FG5-101), or to monitor the rifting of Iceland (FG5-101, JILAg-3 and JILAg-5); Ardenne and Roer graben studies (FG5-202));
- sea level changes (e.g. tide gauge stations around UK (FG5-103), along the Mediterranean coast (SELF-project, FG5-101 and IMGC), or along the German coast (JILAg-3 and FG5-101));
- international gravity network (campaigns of US-NIMA within Eastern Europe in the 1990's, measured with FG5-107, FG5-101 and IMGC; the UNIGRACE-project from 1997 to 2001 with JILAg-5, FG5-101, JILAg-6, FG5-206 and ZZG);
- study of temporal variations of the gravity field with super-conducting gravimeter and absolute gravimeter time series (Bad Homburg, Wettzell, Moxa, Vienna, Membach, Medicina, Strasbourg, Metsähovi, Ny-Alesund).

Today's results show clearly that, only in conjunction, absolute and super conducting gravimeters constitute a tool able to achieve the ∶ Gal-range in gravity measurements and they offer therefore a basis for research on secular gravity and height variations.

The proposal is to establish a EUROPEAN COMBINED GEODETIC NETWORK (ECGN) to combine the spatial and height reference system with Earth gravity field parameter estimation. It is in agreement with the planned IAG project of an Integrated Global Geodetic Observation System (IGGOS). (RUMMEL et al. 2000, RUMMEL 2000)

Description of the Proposal

Background

One of the fundamental development potentials of geodesy for the present and the near future lies in the improvement of the accuracy level and the increase of availability of the Earth's gravity-field-related height component. Whereas during the past 10 years positioning made dramatic progress in accuracy and operability, there was no substantial development in the Earth's gravity-field-related height components.

Today, GPS positioning is used for referencing basic geospatial data, and in conjunction with geoinformation systems GPS, has superseded traditional terrestrial methods of positioning in both science and practical applications, including the European administrative sectors. On the other hand, precise height determination, which is an integral component of geodetic positioning, continues to be based on classical terrestrial methods, which accuracies of 10^{-6} to 10^{-7}, falls short of three-dimensional GPS positioning by the order of two. Since the classical terrestrial methods are restricted to their respective continents, there is no standardized reference system of heights on the global level (figure 1).

In Europe, the reproduction cycle of the height reference systems takes about 30 years. Consequently, the height component from levelling for GPS positioning is not available with the same accuracy and operationally. This fact not only considerably impairs the referencing of geoinformation systems through GPS as to their overall efficiency, but also the performance of scientific kinematic and dynamic studies and investigations of the geosphere.

The contradiction in accuracy and operability between GPS positioning and the levelling of heights can be solved by using geoid solutions with an adequate accuracy (1 cm). They are used for reducing the GPS heights to heights referenced to the Earth's gravity field. The presently available geoid solutions are characterized by long- and medium-wave errors (> 100 km), which can be ascribed primarily to inhomogeneities of the different height systems, and also to the insufficient density and inhomogeneity of the terrestrial gravity data (figure 2, IHDE et al. 2000).

It is expected that the satellite gravity field missions CHAMP, GRACE and GOCE will bring a considerably improvement to the determination of the long- and medium-wave portion of the gravity field. The short-wave components of the Earth's gravity field, which in the long run ensures the continuity of 1 cm accuracy level on the local scales, also will have to be acquired by means of terrestrial gravity data.

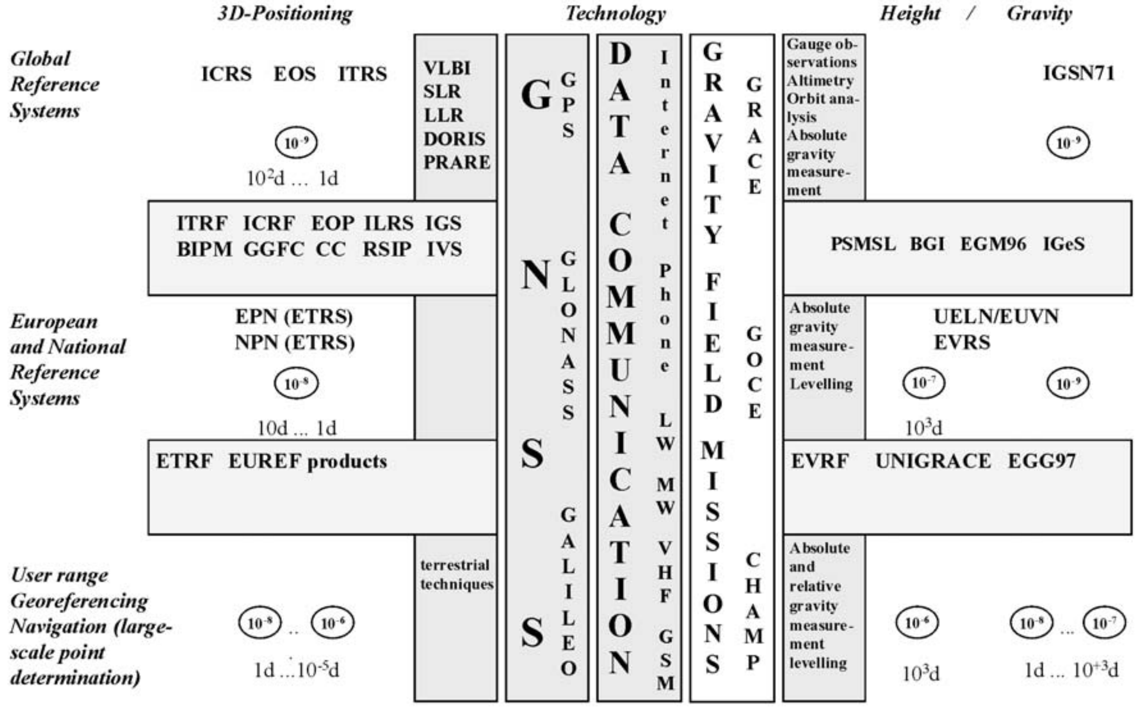


Figure 1: Positioning and Gravity

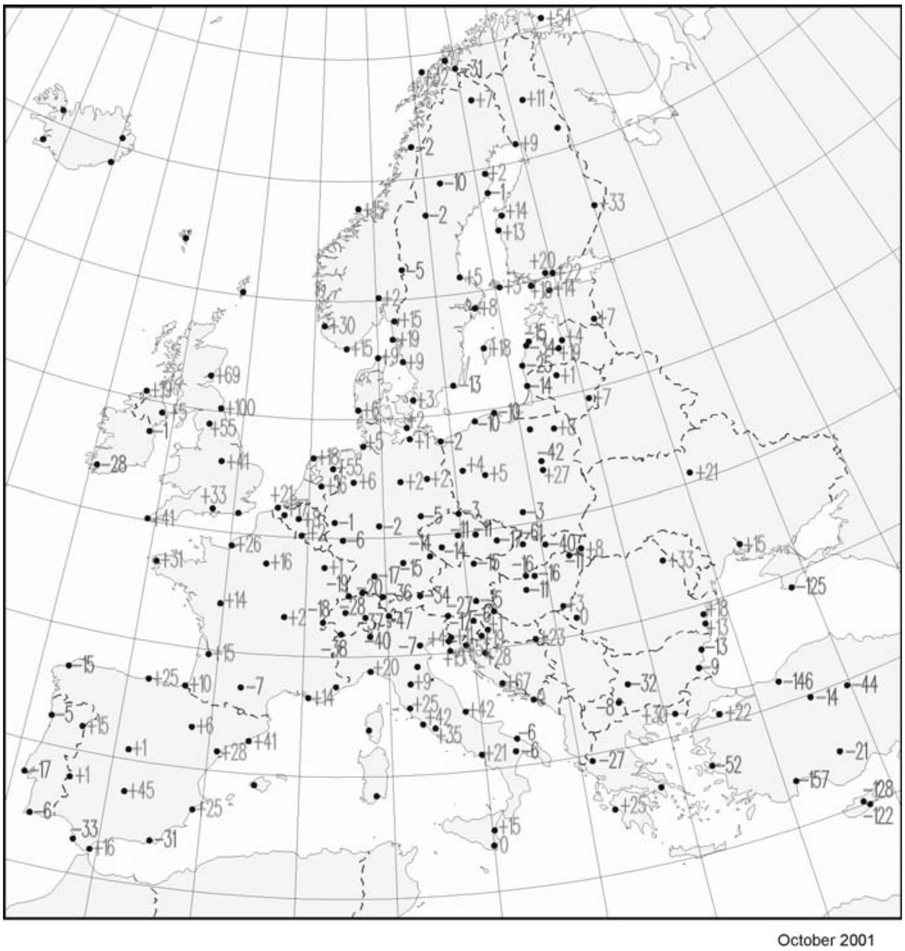


Figure 2: Differences between gravimetric heights ($z_{EGG97} + H_{EUVN}$) and GPS heights h_{ETRS89} in cm derived by the EUVN project

Therefore, it is necessary to combine the data derived from satellite gravity field missions with terrestrial gravity data, that have been reduced to a standardized height level. During a first phase, combinations of GPS observations and classical levelling measurements may serve to represent fiducial points for the combined solution.

The experiences within the EUVN project (IHDE et al. 1999) have shown the practical and methodological problems with the combination of different geodetic observation techniques, especially geometrical and gravity field related data. To give an idea of this, the relations between ITRS/ETRS89 and EVRS (defined as a world height system (WHS) in the components conventions, parameters, and realization) are given in table 1 (IHDE et al. 2000, IHDE et al. 2002). For the combination of the spatial (geometrical) and Earth gravity related components a unique integrated reference system has to be defined and realized.

Table 1: Relations between ITRS and EVRS/WHS (conventions, parameters, realization)

ITRS IUGG Resolution No. 2, Vienna 1991	WHS/EVRS IAG Subcommission for Europe, Resolution No. 5, Tromsø 2000
origin	
(Explicit) Geocentric, the center of mass being defined or the whole Earth, including oceans ***(Implicit)*** and atmosphere	
orientation	
Initial BIH orientation. No global residual rotation with respect to horizontal motions at the Earth's surface.	No necessary convention
units-scale	
SI unit meter The ITRS scale consistent with the Geocentric Coordinate Time (TCG)	SI units meter and seconds The scale of the Earth body W_o is approximated by the normal potential of the mean Earth ellipsoid U_o which includes the masses of the oceans and the atmosphere
coordinates	
quasi-Cartesian system X	potential of the Earth gravity field $W_p = W(X) = U_p + T_p$ (GPM) $= W_o - C_p$ (Levelling)
system parameters	
	mean Earth ellipsoid (U_o, GM, J_2, w)
realization	
ITRF 2000 tide-free	EVRF 2000 (UELN 95/98, ETRS89, GRS 80) $W_p = W_{NAP} + C_p$ (Levelling) , zero tidal system

Figure 3 shows the heights of the mean sea level at the epoch 1997.5 above the GPS/levelling quasi geoid of the EUVN (WÖPPELMANN et al 2000). In Europe in many countries repeated levellings carried out, but they are not available in any case. The repeated levellings available in the UELN/EVRS data base are represented in figure 4 (SACHER et al. 2002).

Table 2 shows the components of an integrated geodetic reference system and their dependence on the tidal systems. It shows that a unique concept for the reduction of observations and related parameters is necessary. Only the origin of both is identically defined. For a height system, a zero level surface has to be agreed on. W_0 as zero level has the advantage that in regard to the semi-major axis and the flattening of the mean Earth ellipsoid it is independent from the tidal system. The main difference has to be considered at the realization: The ITRS/ITRFyy coordinates are given in the non-tidal system, the EVRS heights are given in the zero tidal system.

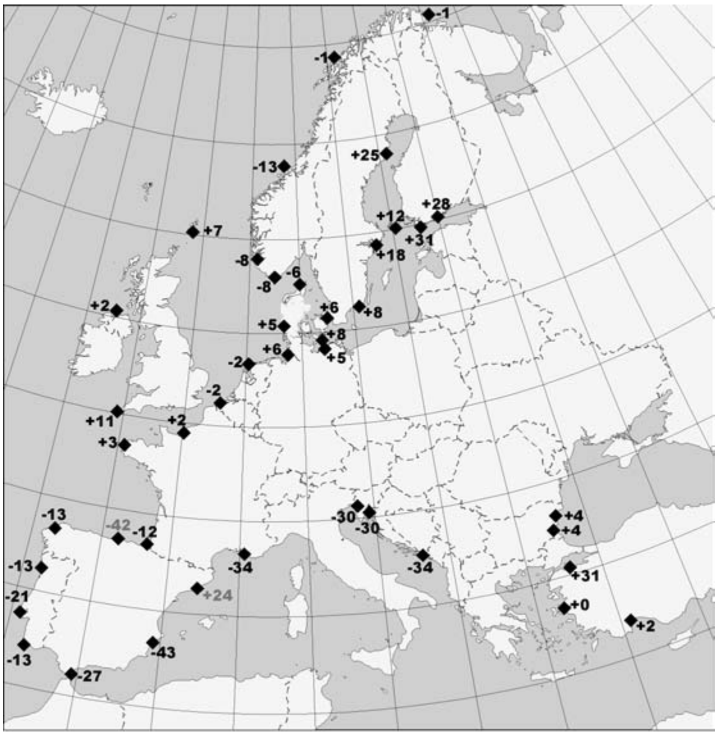


Figure 3: Heights of the mean sea level at the epoch 1997.5 above the GPS/levelling quasi geoid of the EUVN

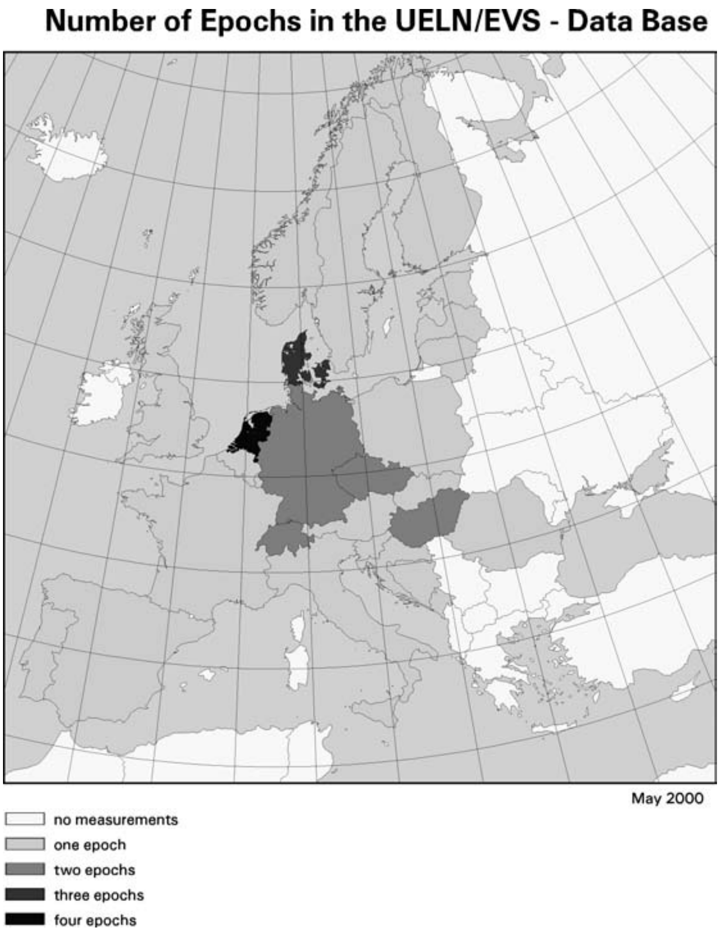


Figure 4: UELN/EVRS data base with number of repeated levellings

Table 2: Components of an integrated geodetic system and their dependence from tidal systems

	gravity g/Dg		geoid W/N	levelling height DH	altimetry h	mean sea level msl	position X/h
Mean tidal system **Mean/zero crust** (Stokes is not valid if masses outside the Earth surface)	Dg_m		N_m	DH_m	Relation to N_m for oceano-graphic studies	h_{msl}	
Zero tidal system **Zero/mean crust** (Recommended by IAG Res. No. 16, 1983)	Dg_z	Stokes ⟶	N_z (EGG97)	(EVRF2000) DH_z			
Non-tidal system **Non-tidal crust** (far away from the real earth shape – there is no reason for the non tidal concept)	Dg_z	Stokes ⟶	N_z (EGM96)				X_n ITRFyy, ETRS89

Gravity related components are given in a zero tidal system, conforming to the IAG Resolutions No 16 adopted in Hamburg in 1983 and to the handling of the gravity data. Contrary to this, the ITRFyy coordinates are given in the non-tidal system, the same holds for the global geopotential model EGM96. The European geoid was reduced to the zero tidal system. The non-tidal system/crust is far off the real Earth shape – there is no justification for the non tidal concept. The Stokes formula is not valid for the mean tidal system, but the mean sea level is reduced to the mean/zero geoid for oceanic studies.

Goals/ Project Objectives

Securing and maintaining the spatial reference frame for positioning and gravity-field-related heights, is one of the core tasks of EUREF. The strategic objective of this project is to realize an integrated geodetic reference frame for the entire territory of Europe.

In order to ensure the long-time stability of the terrestrial reference system with an accuracy of 10^{-9} at both the European and global scale, the interaction between the different time dependent influences of the system Earth on the terrestrial reference system and the related observation has to be considered in the evaluation models.

The availability of the reference frame for real-time and near-real-time positioning needs a high sensitive modelling of the time dependent phenomena of the solid Earth, the Earth gravity field, the ocean, the atmosphere and the hydrosphere. The recording of relevant data to describe and model these phenomena is an integrated part of the maintenance of the terrestrial reference system.

The height is the most important component of the three-dimensional positions of the participating ECGN stations is the height. However, in the regional or global terrestrial reference system, heights are less accurately determined than the horizontal components. This is due to the geometry and the properties of the (mostly spatial) observations which are sensitive to various systematic errors. Therefore, improvements can be expected from the careful combination of different spatial observation techniques (preferably at the observation level), such as GPS and Satellite Laser Ranging (SLR), collocated at the same sites, taking into account the strengths (and weaknesses) of each individual technique.

The complement of the geometrical positioning with the physical height component of matching accuracy, operability and efficiency needs the gravity and a high-precise geoid in the cm-accuracy range. The project contributes to gravity field modelling for the area of Europe and the generation of the best possible global model.

The planned activities aim to link the spatial reference system with gravity field related parameters in order to contribute to a consistent description of the general processes of the system Earth. These processes shall be kinematically integrated into a combined monitoring system of position and gravity. Products of the satellite gravity field missions will be combined with the data of the integrated geodetic terrestrial reference frame.

On the one hand, absolute gravity time series are key information for long time stabilization of height reference systems. On the other hand, gravity time series needs precise position information to extract position variations from gravity variations.

It is a matter of course that the European spatial reference system realized by the EPN is based on, resp. contributes to, global systems and therefore is also a component of the latter. Consequently, the entire project must be seen in the global context. The work on the integrated kinematic network must be understood as a European contribution to a global integrated geodetic network. EUREF wants to support with this project the activities towards an improvement of the European height reference system for scientific work and for the supply of relevant data to European authorities and institutions.

The analysis of GPS time series shows that the height component is not sufficient verified. The combination with other data with vertical information gives the possibility to stabilize the vertical velocities. The main technological aspect is the combination of time series of different techniques.

The project continues the tradition of the EUVN into a next stage. EUVN was especially related to the height component and the realization of a European kinematical height reference system with a continental accuracy of one cm by using time series of different observation techniques. For this it is necessary to consider the variation of the Earth surface and the gravity field.

The proposed ECGN may substantially contribute to meet the geodetic basic needs of the geoinformation sector within Europe. Moreover, in the course of the further development of the ECGN, the needs and requirements as well as the demands made on a DGPS Real-Time positioning service will be allowed for. Additionally ECGN could be a component of a future European disaster monitoring network. The tasks of the referencing geodata and geodynamic investigations require a precise spatial reference system in real-time or near-real-time which takes into account the complex interrelationships between the solid Earth and the ocean, the atmosphere, and the gravity field. Establishment of this network is carried out in accordance with the technological state of the art of positioning by means of satellite navigation systems and considers the foreseeable developments in the user strategies

Principles of Network Structure

The ECGN is a European network for the integration of the spatial geodetic reference frame (GNSS - GPS/GLONASS and in the future GALILEO), gravity field related parameters (gravity, tides, ocean tides), and supplementary information (meteorological parameters, surrounding information of the stations e.g. eccentricities and ground water level) in a kinematic mode.

ECGN is the frame for the integration of spatial reference and the gravity field, the guiding principle consisting in making available time series of the methods to be combined on all stations involved especially:

- Position through GNSS (GPS/GLONASS, GALILEO) with 10^{-9} and better – permanent,
- Gravity (absolute gravity measurements) with microGal – repeated,
- Gravity field-related heights (linkage of levelling to the EVRS) with 1 mm/km – repeated.

On some selected stations the following data should be acquired in addition:

- Ocean tides and sea level changes (tide gauges at the European coast lines) – permanent,
- High-frequency gravity variations (measurements by means of super conducting gravimeter) – permanent,
- Vapour concentration in the atmosphere (vapour radiometer) – permanent.

Supplementary:

- Meteorological parameters – permanent,
- Eccentricities, local control network– repeated,
- Groundwater gauges – permanent.

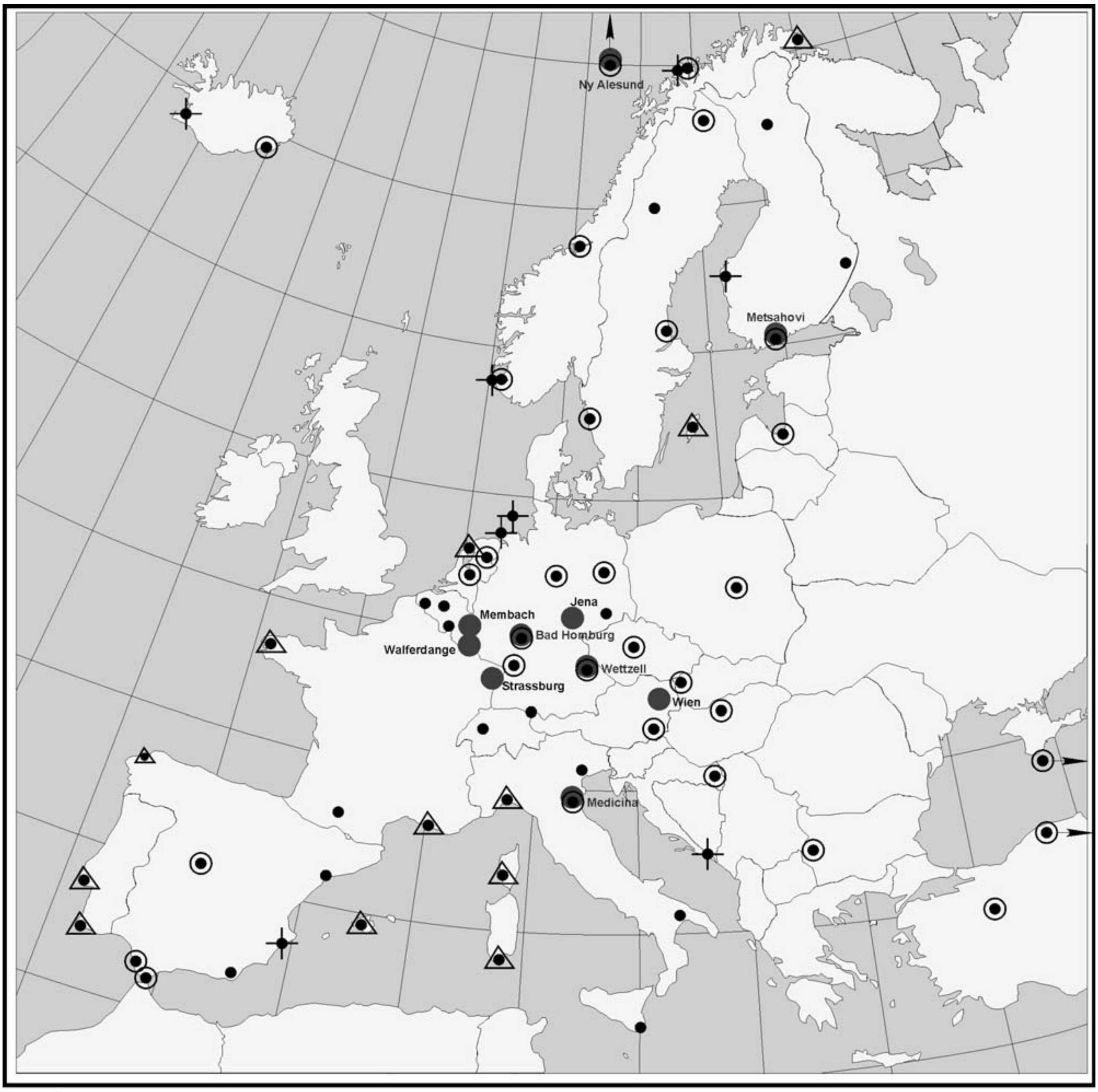
About 65 stations of EUREF's GPS permanent network EPN fulfil the principles of the network structure (figure 5, table 3):

- 15 of them combine GPS and levelling,
- 37 of them combine GPS, levelling and absolute gravity,
- 10 of them are GPS/levelling/tide gauge stations and
- 8 of them are GPS/levelling/gravity/tide gauge stations.

It is proposed to qualify about 10 stations as core stations. Core stations should give the possibility to study the combination of different observation techniques and kinematical effects in case.

Local data centers for the gravity data and sea surface observations and combination research centers should be established.

The available infrastructure of EPN and UELN/EVRS should be left untouched but combined with new elements.



Legend:

- EPN station with GPS, and levelling
- EPN station with GPS, absolute gravity, and levelling
- EPN station with GPS, tide gauge, and levelling
- EPN station with GPS, tide gauge, absolute gravity (and levelling)
- Distribution of superconducting gravimeter in Europe

Figure 5: Candidate Stations of European Combined Geodetic Network (ECGN) – Draft

Call for Participation

The call for participation is from the point of view of time structured in two stages. The first call is directed to the implementation of the ECGN stations following the concept of the project. In parallel the ECGN working group will prepare the second call of analysis and investigations. In the first step, the main action of the ECGN working group will be a pilot study of the combination of the different observations using available collocations at stations e.g. Medicina, Wettzell etc. and this to get experiences in the combination of spatial information with gravity field related data.

1st Call: Observation

This call concerns the elaboration of the observation network of ECGN stations. The ECGN stations have the standard observation techniques

- GNSS (GPS/GLONASS, GALILEO) – permanent,
- Gravity (super conducting gravimeter and/or absolute gravimeter) – permanent or repeated,
- Levelling connections to nodal points of UELN/EVRS – repeated,
- Meteorological parameters – permanent.

For the realisation of the EVRS, the connection to tide gauge projects and the recording of vertical changes between sea level and the solid Earth surface, it is necessary to include selected tide gauges (permanent) along European coast lines.

Standard for the ECGN stations is a local network for the determination of eccentricities at a 1 mm accuracy level in all three spatial components (repeated). All types of observation techniques at a ECGN station should be situated within a distance of about 1 km.

Optional are the establishment of ground water gauges at gravity stations and absolute gravity observations at tide gauge stations.

All ECGN stations are part of the EPN. For GNSS observations and data flow, the guidelines for EPN stations & Operational Centres (*http://www.epncb.oma.be/guidelin.html*) have to be fulfilled.

For super conducting gravimeter observations, the agreements and standards of the Global Geodynamic Project (GGP) are definite (*http://www.eas.slu.edu/GGP/ggpas.html*).

For absolute gravity measurements, agreements and standards are in preparation, including data formats for archiving (Annex 1).

The tide gauges have to be realized following the requirements of the Permanent Service of Mean Sea Level PSMSL (*http://www.pol.ac.uk/psmsl/datainfo/contrib.html*).

Methodology and Analysis (Second Call)

For super conducting gravimeter data, the GGP data centre could be used for data collection. Levelling data of ECGN will be collected at the UELN/EVRS data center. Local data centers for absolute gravity data and super conducting gravimeter data should be installed in the first stage by the ECGN working group.

In a second call it could be asked for

- Analysis centers for the combination of time series observations of all ECGN stations
- Combination of space techniques (GPS, VLBI, SLR)
- Methodical investigations for the combination of spatial observation data with gravity field-related data

Proposal

Proposals submitted in response to the 1st Call for Participation must include specific details on the technical support that will be offered by the organization and a management plan. These two main proposal sections will be used for proposal evaluation and to facilitate comparative analysis. Proposals must be signed by an official authorized to certify institutional support, sponsorship and management of the proposed activities.

To start with the project activities and the coordination of the project, a very stringent schedule is to be observed. Due to the importance of the project, groups may join at any time afterwards during the time of the project.

The Proposal must contain:

- Cover Page (see below),
- Proposal Summary,
- Description of Proposed Activities,
- Management Proposal,
- Financial Arrangements.

The Cover Page should contain: parent/funding organization, name and title of authorizing official, name and title of primary point of contact, mailing address, phone/fax/e-mail, cooperation organizations/ institutes, signatures (the cover page should be signed both by the Authorizing Official committing the organization/institution to the proposal and the primary point of contact involved).

Deadline for the proposals is the 26. April 2003. Please send your proposal via postal mail to the EUREF chair and the EUREF Secretary:

For easier distribution to the reviewers, an additional e-mail version should be made available (in ASCII or attached Word file). Please send the email version to *ecgn@bkg.bund.de*

Proposals should not exceed 10 pages.

Proposal Evaluation and Selection

The principal criteria considered in evaluating the proposal are their relevance to the EUREF ECGN objectives, their intrinsic merit, and overall contribution to the service when compared to contributions available through other proposals. In addition to these criteria, management factors will be considered in the selection.

If ECGN decides to accept only a portion of the proposal, the submitting organization will be given the opportunity to accept or decline such partial acceptance.

Action plan of EUREF ECGN activities

– Appointment of the members of the ECGN WG – Nov. 2002
– Call for participation stage 1 observation – Feb. 15, 2003
– Proposals stage 1 observation – April 26, 2003
– Kick off meeting of the ECGN WG and Proposal evaluation and selection – May 2003
– Report to the EUREF symposium 2003 – June 2003
– Call for participation stage 2 analysis – Oct. 2003

Organization

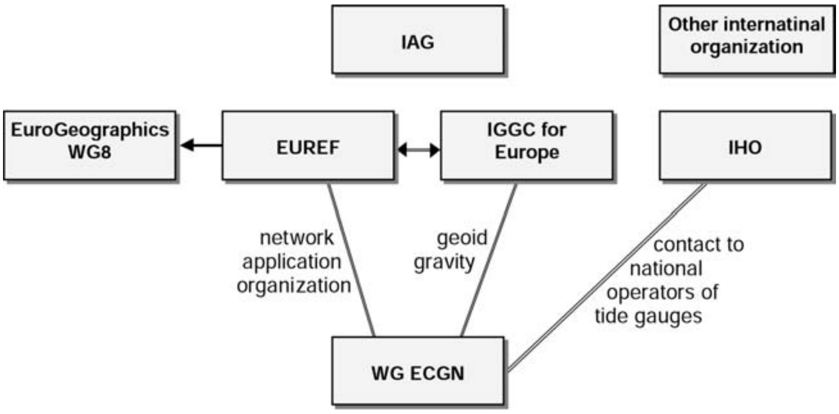


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Table 3: Candidate ECGN stations (Draft)

Logfile	Site Name	Code	DOMES #	Lat.	Long.	Height (m) (Ellip)	Anthgt	Country	Position 0=coast 1=nearby >20km 2=inland	Tide gauge 0=complete 1=incomplete 2=Station close	EUVN-No (close to EPN Point)	Normal-Height in UELN-95/98	absolute gravity measurement	Super	SLR	VLBI	other Technologies
acor0201	A Coruna	ACOR	13434M001	43,364	351,601	67	3,042	ES	0	0	ES05	12.123					
ajac0002	Ajaccio	AJAC	10077M005	41,928	8,763	99	0,000	FR	0	1	FR01	47.728			mobile		
alac0201	Alicante	ALAC	13433M001	38,339	359,519	60	3,035	ES	0	0	ES01	9.998	1998				
alme0112	Almeria	ALME	13437M001	36,936	357,541	127	3,044	ES	0	2		74,251					
ankr0103	Ankara/Turkey	ANKR	20805M002	39,888	32,759	975	0,060	TR	2			939,301	1996				
	Bad Homburg			50,229	8,611	190		DE	2				time series	yes			
bork0110	Borkum	BORK	14268M001	53.6	6.747	54	0.1	DE	0	0			2001				
bogo0108	Borowa Gora	BOGO	12207M002	52,476	21,035	150	0,000	PL	2			108,760	1980; 1992 ;1995; 1996; 1997; 2000				
ptbb0105	Braunschweig	PTBB	14234M001	52.3	10.46	130	0.1	DE	2				1977; 1994; 2000				

Logfile	Site Name	Code	DOMES #	Lat.	Long.	Height (m) (Ellip)	Anthgt	Country	Position 0=coast 1=nearby >20km 2=inland	Tide gauge 0=complete 1=incomplete 2=Station close	EUVN-No (close to EPN Point)	Normal-Height in UELN-95/98	absolute gravity measurement	Super	SLR	VLBI	other Technologies
brst0201	Brest	BRST	10004M004	48,381	355,503	22	1,054	FR	0	0	FR04	53,301					
brus0103	Brussels	BRUS	13101M004	50,798	4,359	150	3,970	BE	2			104,437	1995;1997 now own FG5				
cagl0107	Cagliari – Astronomy	CAGL	12725M003	39,136	8,973	238	0,045	IT	0	1	IT11	14.681			permanent		
casc9911	Cascais	CASC	13909S001	38,693	350,582	77	1,021	PT	0	0	PT02	12.147					
ceut0111	Ceuta	CEUT	13449M001	35,896	354,689	52	0,000	ES		2			1994; 1998				
dent0001	Dentergem	DENT	13112M001	50,934	3,400	64	0,754	BE	2			19,518					
dour0110	Dourbes	DOUR	13113M001	50,095	4,595	283	0,753	FR	2			236,643					
dres0105	Dresden	DRES	14108M001	51	13.73	203	0.6	DE	2				1994				
dubr0103	Dubrovnik	DUBR	11901M001	42,650	18,110	454	0,081	HR	0	0	HR03	5.347	1999; 2000				
ebre9907	Ebre	EBRE	13410M001	40,821	0,492	108	0,000	ES	1	2		57,708					

Logfile	Site Name	Code	DOMES #	Lat.	Long.	Height (m) (Ellip)	Anthgt	Country	Position 0=coast 1=nearby >20km 2=inland	Tide gauge 0=complete 1=incomplete 2=Station close	EUVN-No (close to EPN Point)	Normal-Height in UELN-95/98	absolute gravity measurement	Super	SLR	VLBI	other Technologies
penc0104	FOMI Satellite Geode	PENC	11206M006	47.8	19.28	292	0	HU	2			248.387	1998; 2000				
geno0202	Genova – Istituto Id	GENO	12712M002	44,419	8,921	137	0,000	IT	0	1	IT05	4,014					
graz0106	Graz-Lustbuehel	GRAZ	11001M002	47,067	15,494	538	1,964	AT	2			490,925	1998; 2001				
helg0103	Helgoland Island / G	HELG	14264M001	54,175	7,893	48	0,065	DE	0	0			1997; 2001				
hofn0109	Hoefn / Iceland	HOFN	10204M002	64,267	344,802	82	0,051	IS	1				1997; 1998			mobile (1992)	PRARE (permanent)
joen0201	Joensuu permanent GP	JOEN	10512M001	62,391	30,096	114	0,000	FI	2			96,694	1999				
joze0104	Jozefoslaw	JOZE	12204M001	52,086	21,033	141	0,198	PL	2			110,244	time series Jozefoslaw				
karl0105	Karlsruhe	KARL	14216M001	49,011	8,411	183	0,065	DE	2				1988; 1993; 1994; 1995				
kely0110	Kellyville (Kangerlu)	KELY	43005M001	66,987	309,055	231	0,076	DK					1995; 1996; 1997; 1998;1999				
kiru0010	Kiruna	KIRU	10403M002	67,857	20,968	0	0,062	SE	2				1995				

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kir00201	Kiruna	KIR0	10422M001	67.9	21.06	498	0.1	SE	2			469,536	1995				
klop0105	Kloppenheim	KLOP	14214M002	50,220	8,730	222	0,069	DE	2				time series Bad Homburg?				
kosg0103	Kootwijk Observatory	KOSG	13504M003	52,178	5,810	98	0,105	NL	2			53,589	1991; 1996				
lago0005	Lagos	LAGO	13903M001	37.1	351.3	63	0	PT	0	0	PT05	2.597					
mar60201	Maartsbo	MAR6	10405M002	60.6	17.26	75	0.1	SE	1	2		50,728	1993; 1995				
mad29911	Madrid Deep Space Tr	MAD2	13407S012	40,429	355,750	0	0,025	ES	2				1989; 1998; now own 'FG5				
madr0006	Madrid Deep Space Tr	MADR	13407S012	40,429	355,750	0	0,025	ES	2			762,103	1989; 1998; now own FG5				
mars0201	Marseille	MARS	10073M008	43,279	5,354	62	0,070	FR	0	0	FR06	12.394					
mate0201	Matera	MATE	12734M008	40.6	16.71	535	0.1	IT	2			490.042			permanent	permanent	PRARE
medi0104	Medicina (BO) – Radi	MEDI	12711M003	44,520	11,647	50	0,000	IT	2				time series since 1996	yes			

Logfile	Site Name	Code	DOMES #	Lat.	Long.	Height (m) (Ellip)	Anthgt	Country	Position 0=coast 1=nearby >20km 2=inland	Tide gauge 0=complete 1=incomplete 2=Station close	EUVN-No (close to EPN Point)	Normal-Height in UELN-95/98	absolute gravity measurement	Super	SLR	VLBI	other Technologies
	Membach			50,617	6,000	250		BE	2				time series	yes			
mets0105	Metsahovi	METS	10503S011	60,218	24,395	95	0,000	FI	1	2		75,986	time series	yes	permanent	mobile (1989); permanent under construction	DORIS (permanent), SG
mopi0201	Modra-Piesok	MOPI	11507M001	48.4	17.27	579	0.1	SK	2				1998; 2000				
	Moxa			50,645	11,616	455		DE	2					yes			
noto9906	Noto – Radio-astronomy	NOTO	12717M003	36,876	14,990	0	0,000	IT				84,441					
nya10005	Ny-Alesund	NYA1	10317M003	78,920	11,870	83	0,000	NO	0	1			1998; 2000; 2001 time series	yes	yes		DORIS; PRARE
nyal9909	Ny-Alesund	NYAL	10317M001	78,930	11,865	0	5,216	NO	0				1998; 2000; 2001				
onsa0201	Onsola	ONSA	10402M004	57.4	11.93	47	1	SE	1			9.129	1993; 1995; 1998			permanent	GLONASS / GPS
osje0104	Osijek	OSJE	11902M001	45.6	18.68	154	0.1	HR	2				2000				
mall0201	Palma de Mallorca	MALL	13444M001	39,553	2,625	62	0,000	ES	1	2		10.083					

Logfile	Site Name	Code	DOMES #	Lat.	Long.	Height (m) (Ellip)	Anthgt	Country	Position 0=coast 1=nearby >20km 2=inland	Tide gauge 0=complete 1=incomplete 2=Station close	EUVN-No (close to EPN Point)	Normal-Height in UELN-95/98	absolute gravity measurement	Super	SLR	VLBI	other Technologies
gope0201	Pecny, Ondrejov/CZ	GOPE	11502M002	49.9	14.79	593	0	CZ	2			547,696	time series since 1978;now own FG5				
pfan0011	Pfaender/Moos/ Bregenz	PFAN	11005S002	47,517	9,700	1040	0,000	AT	2			1043,183	1988; Bregenz				
pots0107	Potsdam, Geo-Forschuns	POTS	14106M003	52.4	13.07	174	0	DE	2			104.216	76; 78; 80; 83; 86; 88; 90; 94; 97				
reyk0105	Reykjavik/ Iceland	REYK	10202M001	64,139	338,045	93	0,068	IS	0	1	REYK		1988; 1997				DORIS (permanent)
riga0106	RIGA permanent GPS	RIGA	12302M002	56.9	24.06	35	0.1	LV		2		14.017	1995;1996		permanent		
sfer0201	San Fernando	SFER	13402M004	36,464	353,794	86	1,626	ES	1				1994; 1998		permanent		
soda0201	Sodankyla permanent	SODA	10513M001	67.4	26.39	300	0	FI	2			279.309	1976; 1980; 1988; 1992; 1998				
sofi0106	Sofia/Bulgaria	SOFI	11101M002	42.6	23.4	1120	0.22	BG	2				1998; 2001				
stav0001	Stavanger	STAV	10330M001	59	5.599	0	5.56	NO	0	0	NO02	1.886	1991; 1993; 1995				
stas0010	Stavanger	STAS	10330M001	59,018	5,599	105	5,559	NO	0				1991; 1993; 1995				

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	Strasbourg			48,622	7,685	180		FR	2				time series	yes			
ters0103	Terschelling	TERS	13534M001	53,363	5,219	56	0,000	NL	0	1	TERS	14,718					
thu19908	Thule AFB, Greenland	THU1	43001M001	76.5	291.2	55	0	DK					1988				
toul9906	Toulouse	TOUL	10003M004	43.6	1.481	0	0.63	FR	2			157,740					
trab0104	Trabzon / Turkey	TRAB	20808M001	41	39.78	99	0.1	TR		2			1996				
tro19909	Tromsoe	TRO1	10302M006	69.7	18.94	142	0	NO					1992; 1993; 1995; 1998			mobile (Aug-1997)	SATREF
trom9911	Tromsoe	TROM	10302M003	69,663	18,940	0	2,475	NO		1	TROM		1992; 1993; 1995; 1998				
trds0010	Trondheim	TRDS	10331M001	63,371	10,319	318	5,546	NO		2			1995; 1998				
tron0001	Trondheim	TRON	10331M001	63,371	10,319	0	5,546	NO					1995; 1998				
upad0111	University of Padova	UPAD	12750M002	45,407	11,878		1,962	IT	2			39.582					

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vaas0201	Vaasa permanent GPS	VAAS	10511M001	63	21.77	58	0	FI	1	1	VAAS	40.382	1995; 1999				
vard0001	Vardoe	VARD	10322M002	70,336	31,031	0	5,512	NO	0	0	NO12	3.042					
	Vienna			48,249	16,358	192		AT	2					yes			
vil00201	Vilhelmina	VIL0	10424M001	64.7	16.56	450	0.1	SE				420.321					
vis00201	Visby	VIS0	10423M001	57.7	18.37	80	0.1	SE	0	1	VISO	54.846					
	Walferdange			49,665	6,153	295		LU	2				time series	yes			
wsrt0105	Westerbork Synthesis	WSRT	13506M005	52,915	6,605	86	0,389	NL	2			40,747	1991; 1996				
wtzr0108	Wettzell / Germany	WTZR	14201M010	49.1	12.88	666	0.1	DE	2			619.339	time series	yes	permanent	permanent	
zeck0107	Zelenchuks-kaya/Rus	ZECK	12351M001	43,288	41,565	1167	0,045	RU	2				1994				
zimm9908	Zimmerwald L+T 88	ZIMM	14001M004	46,877	7,465	957	0	CH	2			906,877			permanent		