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The Austrian Geodynamic Reference Frame (AGREF) Motivation and Results

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The Austrian Geodynamic Reference Frame (AGREF) Motivation and Results

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Abstract

A summary of the works on AGREF is presented and a review of the accuracy of the results is given. Some prospects of future related activities are mentioned.

Zusammenfassung

Die Arbeiten an AGREF werden zusammengefaßt, die Resultate in Hinblick auf ihre Genauigkeit durchleuchtet und die Zukunftsaussichten betrachtet.

1. Preliminary Remarks

This contribution presents the complementary written summary to a poster presented at the IUGG XXI General Assembly, Boulder, July 2–14, 1995. A special monograph which will contain details of the AGREF activities, including the final coordinates and station documentations, will be published in the course of 1996.

2. Objectives

The objectives remained the same as mentioned in [1], namely to establish a 3D homogeneous reference frame with a total r.m.s. of better than ±1.5 cm, to support the Austrian Geoid at the cm-level, to monitor regional crustal movements, and to link national and international networks.

In future AGREF may also be used for further objectives, like to provide base stations for DGPS and other real time applications.

3. Realization

3.1 Concept

During the last years the accuracy of GPS-coordinates derived from continuous observation periods of some days could be improved in such a way that it competes with SLR/VLBI methods, without however replacing them for global control and special applications like determination of geocentric coordinates and polar motion. Cheap permanently observing GPS-stations are under way to replace fundamental stations, equipped with all kinds of measurement devices, at least for geodynamical applications. The installation of the International GPS Geodynamic Service (IGS) and of the Central Europe Geodynamic Reference Network (CEGRN) was a logical consequence. Austria, presently, contributes with two permanent AGREF GPS-stations (Graz, Hafelekar/Innsbruck) to IGS and CEGRN and, temporarily, operates the AGREF stations Reisseck and Hutbigl for CEGRN.

This development led to a revision of the initial concept of AGREF to use only fundamental stations for linking AGREF to international and global networks by introducing a hierarchic structure. A subset of seven AGREF points (including Graz and Innsbruck) is planned to operate permanently, thus fulfilling all objectives of AGREF mentioned above. A further subset will be monitored periodically (about one week/year) mainly for geodynamic investigations. The remaining bulk of points should serve for national surveying objectives. It is well distributed over the whole national area with a spacing of about 50 km. Except for the improvement of accuracy of some "bad" points and the restitution of lost points no further activity is intended for the moment. Furthermore, a dense network (distances about 20 km) has been installed in a special area of tectonic movements (Carinthia-Friuli-Slovenia). There, measurements will be repeated periodically. Figure 1 presents the state of the art distribution of all Austrian and associated AGREF points.

3.2 Monumentation

Based on the fact that most of the measurement errors are introduced by the definition of the reference point and eccentricity problems of the antennas special brass bolts were used as a cheap and reliable monumentation, which allows for a plain re-occupation without using tripods. All bolts were founded in bedrock, pillars or old buildings obeying the usual criteria for GPS-observations. Only very few points had to be observed at eccenters. Presently the distribution is as follows:

Austria: 81 points (bedrock 48, pillars 12, others 21)
Croatia: 11 points (bedrock 2, pillars 6, others 3)
Italy: 17 points (bedrock 8, pillars 4, others 5)
Slovenia: 20 points (bedrock 14, pillars 4, others 2)

These numbers are temporarily changing due to the inclusion of of new areas of interest.

3.3. Measurements

During the years 1990–1995 99% of these points have been measured at least twice during several campaigns. Starting with Ashtech receivers, Trimble and Rogue receivers have been used during the last 3 years. The occupation time could be extended from six hours in 1990 to 24 hours in 1994, mainly due to the upgrading of the GPS space segment. All data were stored at the Graz observatory. During the 1992 campaign 25% of the Croatian and German receivers showed malfunctions in L2. Since, unfortunately, the bulk of points was observed during that campaign, this was a major setback for determining an accurate solution of AGREF.

4. Results

4.1 Adjustment

The computations were carried out using the Bernese Software in its various versions (mainly 3.4), adopting ITRF92 at epoch 1988.0 as the reference frame. The results of the campaigns prior to 1992 were transformed to this solution via identical points. The main complications were introduced by the 1992 data, which had to be processed at least twice to get reasonable results for most of the points.

All sessions were computed independently. The final coordinates and their r.m.s errors were computed from those daily solutions. All important session products have been stored at the Graz observatory.

4.2 Results

During the last years the update of the satellite constellation and the availability of precise orbits and clocks provided by IGS led to a considerable increase of the accuracy of GPS-derived coordinates which is demonstrated by the following statistics:

46% of all points have an r.m.s. of below ± 1 cm;
27% of all points have an r.m.s. of between ± 1 and ± 2 cm;
27% of all points fail the required accuracy requirements and need additional measurements.

All points failing the required accuracy were determined during 1990 or 1992. The main problem concerns the height component, because 69% of all points have horizontal r.m.s. of below

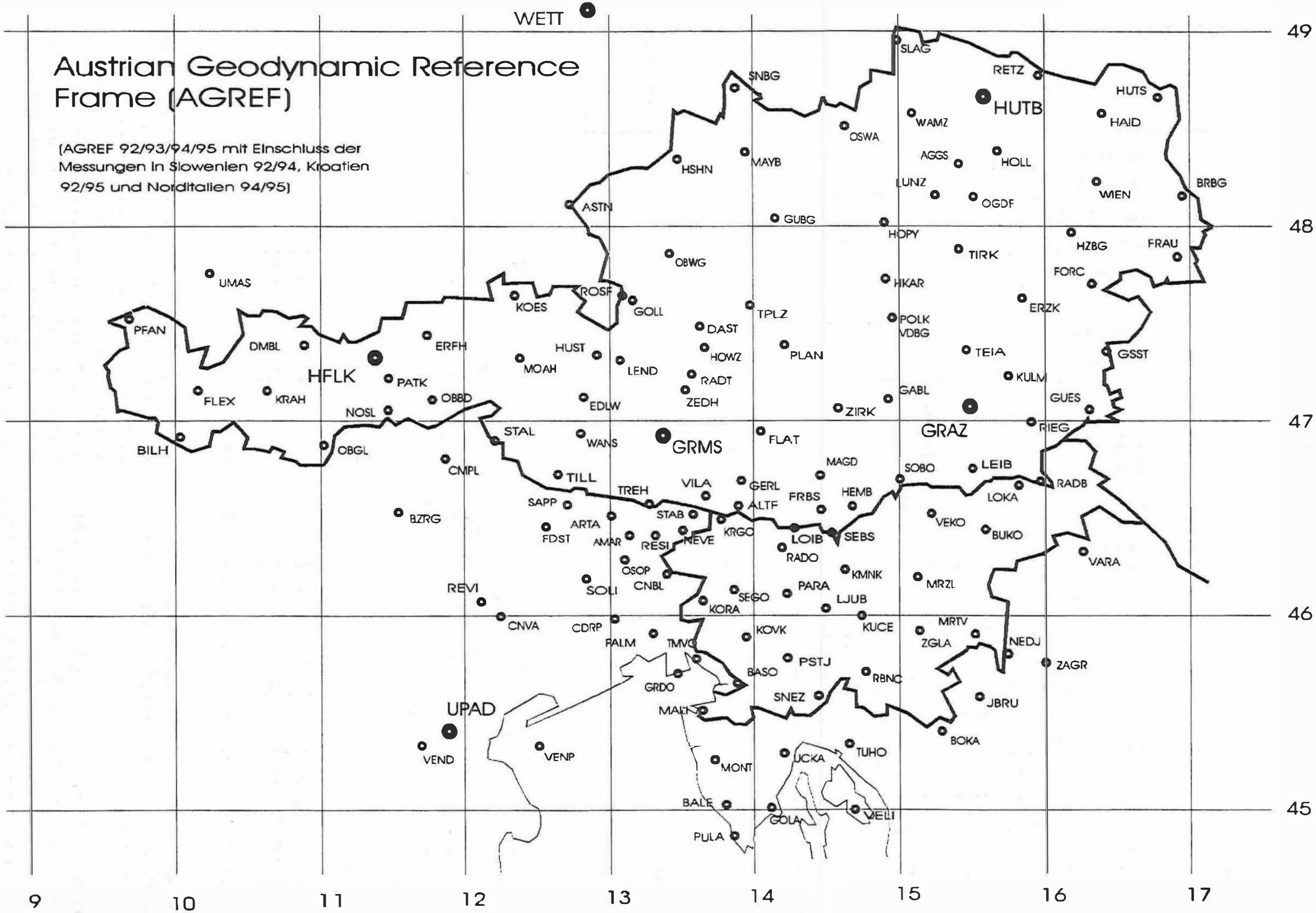

Fig. 1 : Distribution of AGREF points; status end of 1995.

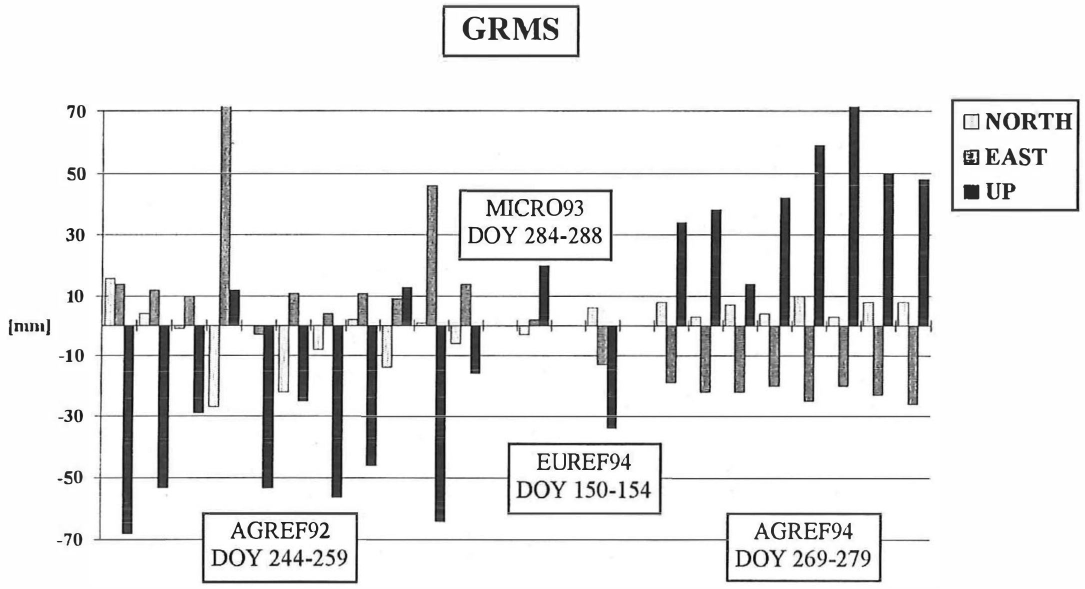

Fig. 2 : AGREF Session Differences (Bad Example)

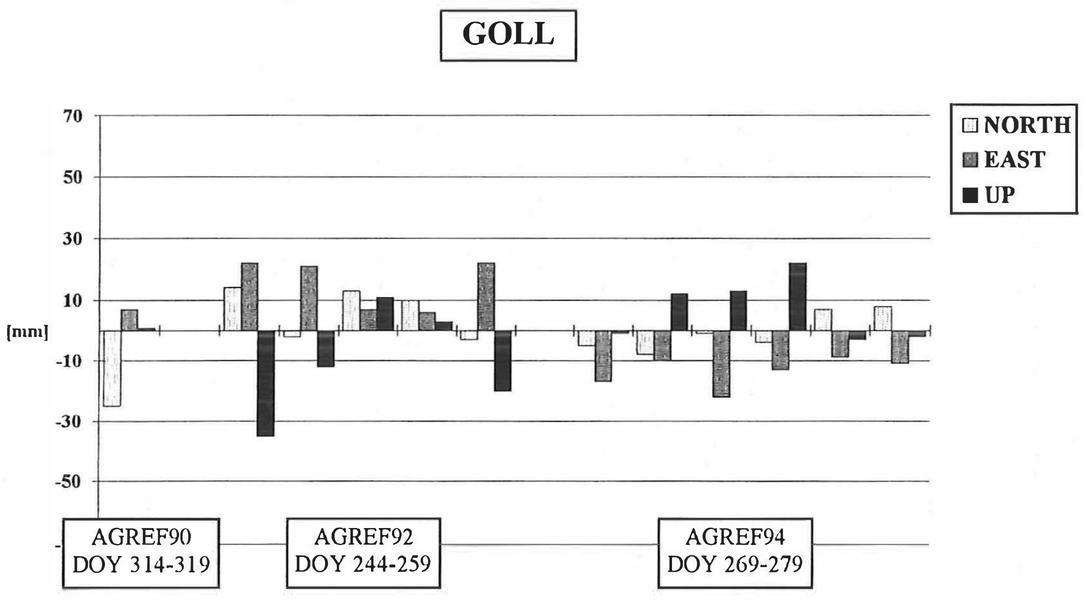

Fig. 3 : AGREF Session Differences (Representative Example)

± 1 cm and only 27% horizontal r.m.s. between ± 1 cm and ± 2 cm, leaving 4% with unsufficient horizontal accuracy.

Figure 2 shows a bad example, the site GRMS. During 1990 to 1993 unstable horizontal components are joined by considerable height differences. The earlier data did not allow for reasonable tropospheric zenith delay estimations, which proved fatal for this point with an altitude of 2300 meters. Since 1994 the horizontal components remained stable, the height still showing some offshots of more than three centimeters. During 1995 (not shown in the figure) the situation improved to a resulting maximum height difference of below two centimeters.

STATION	RMS[MM]				STATION	RMS[MM]			
	X	Y	Z			X	Y	Z	
AGGS	0	0	2	1)	GSST	7	1	9	
ALTF	4	6	23		GUBG	3	0	1	1)
ARTA	4	3	8		GUES	20	9	1	
ASTN	672	848	1090	2)	GURS	18	11	9	
BALE	9	3	11		HAID	4	5	5	
BASO	4	2	5		HEMB	7	0	1	
BILH	13	4	3		HFLK	4	1	3	
BRBG	69	18	77	1)	HKAR	12	0	12	
BRSK	19	7	15		HOLL	2	4	7	1)
BUKO	39	6	4		HOPY	5	3	7	
BZRG	3	2	3		HOWZ	5	8	27	
CDRP	1	1	4		HSHN	3	5	15	1)
CMPL	8	1	8		HUST	5	3	1	
CNBL	3	1	4		HUTB	6	2	6	
CNVA	1	0	0		HUTS	6	7	8	1)
DAST	11	7	5		HZBG	25	9	27	1)
DMBL	4	2	4		JOZE	3	1	3	
EDLW	8	3	3		KMNK	1	0	0	
ERFH	17	13	14		KOES	5	6	6	
ERZK	5	7	5		KORA	2	1	1	
FLAT	2	8	10		KOVK	4	5	2	
FLEX	4	8	8		KRAH	4	1	3	2)
FORC	7	2	0		KRAH94	3	0	0	2)
FRAU	66	70	36		KRGO	18	8	19	
FRBS	25	8	2		KUCE	4	2	4	
GABL	1	9	4		KULM	9	9	9	
GERL	3	3	2	2)	LEIB	4	0	14	
GERP	7	0	0	2)	LEND	16	9	15	
GOLA	6	4	11		LJUB	5	2	2	
GOLL	4	3	3		LOIB	0	0	1	
GRAZ	3	1	3		LOKA	10	7	10	
GRDO	5	3	0		LUNZ	19	5	21	1)
GRMS	5	2	5						

STATION	RMS[MM]				STATION	RMS[MM]			
	X	Y	Z			X	Y	Z	
MAGD	4	0	12		ROSF	12	15	25	
MALI	2	1	2	2)	SEBS	1	1	0	
MALI92	1	13	2	2)	SEGO	0	0	2	
MATE	5	3	5		SEXT	20	7	3	
MAYB	5	2	7		SLAG	7	1	8	1)
MEDI	624	122	629	2)	SNBG	16	17	25	1)
MOAH	17	9	7		SNEZ	10	7	8	
MONT	10	7	3		SOBO	8	2	7	
MRTV	29	12	6		SOLI	5	2	2	
MRZL	5	5	4		STAL	12	9	3	
NEDJ	2	4	13		TEIA	10	5	11	
NEVE	1	3	4		TILL	4	6	3	
NOSL	23	10	10		TIRK	1	3	3	
OBBD	6	2	4		TMVO	1	1	1	
OBGL	1	7	11		TPLZ	3	3	6	
OBWG	7	12	1		TREH	2	1	4	
OGDF	20	2	17	1)	TUHO	15	2	10	
OSWA	2	2	2		UCKA	42	16	53	
PALM	3	2	4		UMAS	19	14	20	
PARA	1	0	2		UPAD	3	1	3	
PFAN	3	4	3		VARA	8	5	2	
PLAN	4	3	4		VDBG	4	6	2	
POLK	44	31	48		VEKO	17	2	2	
PSTJ	3	2	0		VELI	24	3	16	
PULA	3	3	7		VILA	1	1	3	
RADB	12	10	21		WAMZ	18	6	8	1)
RADO	7	7	1		WANS	7	12	8	
RADS	6	1	1		WETT	2	2	4	
RBNC	2	2	1		ZAGR	3	4	5	
RETZ	20	3	14	1)	ZGLA	3	5	6	
REVI	14	6	32		ZIMM	2	3	2	
RIEG	7	8	10		ZIRK	9	19	13	

1) Station values from Helmert Transformation (no external check)
2) Eccenter Determination Pending

Fig. 4 : AGREF Stations : RMS of Mean Values X,Y,Z (ITRF92)

Figure 3 presents the normal case (except the abundance of sessions) at the site GOLL. The differences are much less, but still, until 1994, all components show an unstable behaviour.

Figure 4 gives an overview of the accuracy of AGREF based on data up to end of 1994. Gross errors have been omitted, where possible. Considerable improvements have been attained in some regions since that time. It seems quite logical that each forthcoming well designed campaign may improve the values of some points.

5. Conclusions

The coordinates of AGREF are available now, but yet still unpublished. The horizontal components show a repeatability of below 10 mm with an r.m.s. of the mean tending well below 5 mm. The height can now repeated within 20 mm, the r.m.s. of the mean already remaining below 10 mm. Only points with occupations older than 1994 show worse accuracies. Therefore, the results of AGREF can now be used for several objectives.

AGREF provides a pretty good national representation of the international reference frame. It can be used for purposes of national surveying very well. It also can support geoid computations, but still an improvement in height determination would be desirable. This is even more demanding for geodynamic investigations. Having small tectonic movements in Austria the present accuracy will be the minimum for their fast and precise determination.

The next targets should be the replacements of older results by more precise ones. Additionally, the combination of measured values of the troposphere with its conventional estimation should be investigated to improve the determination of the height component.

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