TECTONIC MOTION OF EUROPEAN VLBI SITES

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1. Introduction

VLBI sites in Europe show very complex motion due to tectonic processes. Regular VLBI sessions help us to trace a individual drift of each site as well as a general overview of the whole network. The sessions have been processed using OCCAM software [Titov, Zarraoa, 1997]. Evolution of European baselines is resulted. Rates of baselength evolution are compared with GSFC ones obtained using CALC/SOLVE software system [Caprette et al., 1990]. Evolution of Ny-Alesund VLBI site is considered in details. Rates of the station component drift are presented. It is concluded that the motion of some VLBI sites can not be approximated by conventional NNR-NUVEL-1A model [DeMets et al., 1994].

2. Observational data and procedure for adjustment

To analyze a tectonic motion of VLBI sites 39 observational sessions on European network (from 26 January 1990 till 17 August 1998) have been processed using OCCAM software. All reductions were made in accordance with IERS Conventions 1996 [McCarthy, 1996]. Kalman filter approach has been used to adjust individual sessions. ICRF 96 system fixed celestial reference frame, IRTF96 positions and NNR-NUVEL-1A velocities approximated the sites motion. VLBI station Wettzell was a reference one for all sessions. Nutation offset to IAU 1980 model, clock offsets and rates as well as wet troposphere delays are estimated. Random walk stochastic model is applied for clock and troposphere parameters approximation.

Next step I analyzed an evolution of baselines using conventional weighted least squares procedure. Baselength for epoch 1999.0 as well as baselength rate were estimated only.

To study a motion of Ny-Alesund VLBI site I have processed 116 observational sessions on different networks (from 04 October 1994 till 01 December 1998) using the same approached as mentioned above. Vertical, latitude and longitude components were estimated for each observational epoch. Temporal evolution of the components is considered.

3. Evolution of European baselines

Table 1 shows a velocity rates for 15 European baselines which have long history of observations (more than five years). They are compared with rates from NASA GSFC global solution August, 1998 [Ma, Ryan, 1998]. The GSFC values were obtained using SOLVE software from all VLBI data files (not European network only).Therefore a standard deviations in second column are better. Both set of rates are in perfect agreement. The OCCAM solution also coincides with other ones specially for European network [for example, Tomasi et al., 1997]. Obviously, the velocity rates do not depend on choice of VLBI

network under process. One can make a conclusion that the OCCAM results in Table 1 are reliable.

NNR-NUVEL-1A model considers all VLBI sites on European tectonic plate exception Noto. In accordance with the model almost all baseline rates should be equal to zero. Nevertheless, the observational rates in Table 1 demonstrates a significant deviation from NNR-NUVEL-1A. Only three baselines made up by Wettzell, Onsala and DSS65 sites look close to the model. All Italian VLBI sites (Medicina, Matera, Noto) approaches to Central Europe. South part of Italy (Matera, Noto) approaches to North part (Medicina) as well. NNR-NUVEL-1A model predicts rate -6.6 mm/year for baseline Matera – Noto which looks more stable. It appears that Matera and Noto should be put on the same tectonic plate. Nevertheless, the complex general motion of Adriatic region to be taken into account for correct modeling of International Terrestrial Reference Frame (ITRF). Probably, more adequate to present-day geodetic results Actual Plate Kinematic Model (APKIM) [Drewes, 1998] would be more appropriate for the purpose.

Baseline	Rate and 3σ error from OCCAM (mm/year)	Rate and 3σ error from SOLVE (mm/year)
Wettzell - Onsala	-0.5 +/- 1.0	-0.4 +/- 0.3
Wettzell - Medicina	-2.4 +/- 0.7	-2.6 +/- 0.6
Wettzell - Matera	-4.1 +/- 1.1	-4.0 +/- 0.6
Wettzell - DSS65	0.0 +/- 1.0	0.5 +/- 0.6
Wettzell - Noto	-5.1 +/- 1.0	-5.1 +/- 0.6
Onsala - Medicina	-2.5 +/- 0.9	-2.7 +/- 0.9
Onsala - Matera	-4.5 +/- 1.3	-4.2 +/- 0.9
Onsala - DSS65	0.0 +/- 1.5	0.3 +/- 0.9
Onsala - Noto	-5.1 +/- 1.1	-4.3 +/- 0.9
Medicina - Matera	-1.8 +/- 0.8	-1.6 +/- 0.6
Medicina - DSS65	2.1 +/- 1.4	2.3 +/- 0.6
Medicina - Noto	-3.7 +/- 0.9	-2.9 +/- 0.9
Matera - DSS65	1.7 +/- 2.0	1.4 +/- 1.2
Matera - Noto	0.3 +/ 1.4	0.5 +/- 0.6
DSS65 - Noto	-2.2 +/- 1.6	-2.3 +/- 1.2

Table 1.
Rates of European baselines from OCCAM
and SOLVE [Ma, Ryan, 1998]

Moreover, evolution of some baselengths differ from simple linear model. Below you can see the plots of post-fit residuals after removing of trend. For example, baseline DSS65 – Medicina (fig.1) shows slow variations with maximum in 1995. Baseline Wettzell – Matera (fig.2) has 2-cm 'jump' at the beginning of 1994. Post-fit residuals from baseline Medicina – Matera (fig.3) show a negative sign before 1996 and positive after the date. If we divide the baseline history into two subsets (before and after 1996.0), we will obtain two independent solutions. The first part of plot (19 points) provides us the rate -3.2 +/- 1.2 mm/year, the second one (8 points) provides the rate 0.3 +/- 5.3 mm/year for the short baseline. The similar picture is for baseline Medicina – Noto (fig.4). Due to limitation of observations after 1996 it is no reasonable to make any final conclusion on evolution of distance between the Italian baselines. Therefore, it is necessary to observe the tendency 3-4 years more.

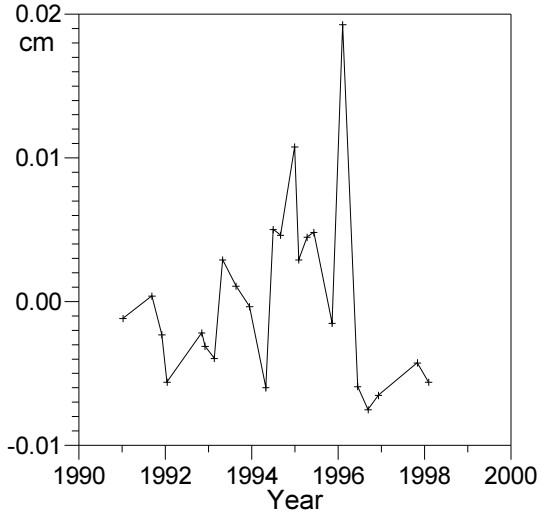

Fig. 1
Baseline DSS65 – MEDICINA

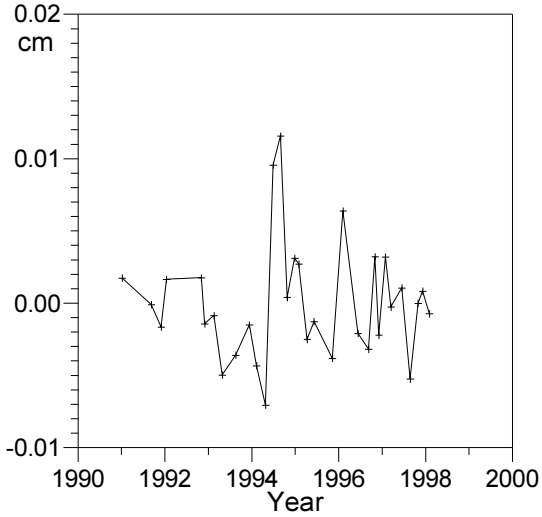

Fig. 2
Baseline WETTZELL – MATERA

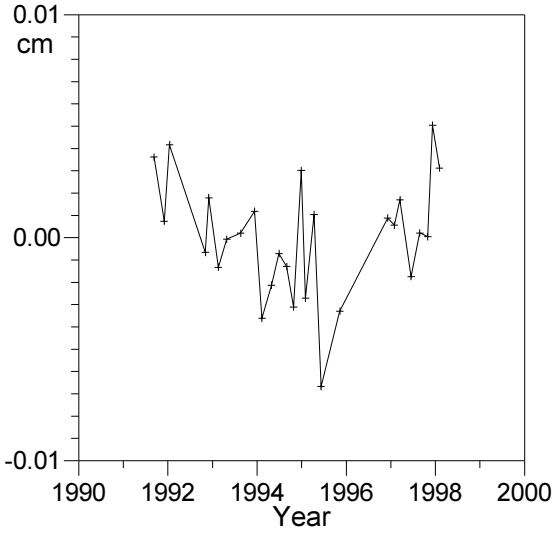

Fig. 3
Baseline MEDICINA – MATERA

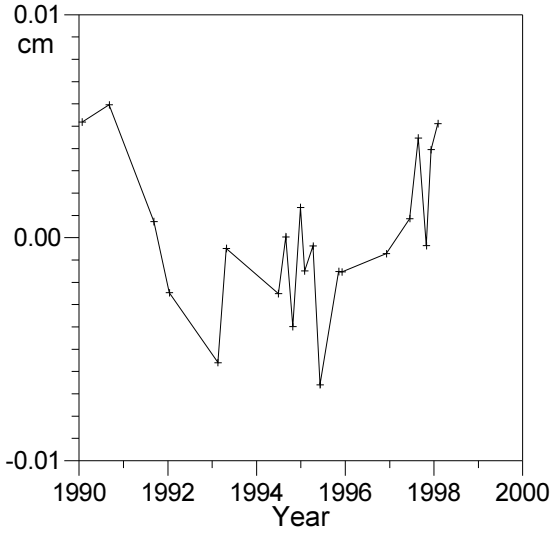

Fig. 4
Baseline MEDICINA – NOTO

4. Motion of Ny-Alesund VLBI station.

VLBI station Ny-Alesund has been installed in 1994 on Svalbard archipelago [Pettersen, 1995]. Since the year Ny-Alesund actively participates in varous observational program actively. Therefore more detailed analysis of the Ny-Alesund tectonic motion to be made for comparatively short four-years observational history. I have processed 116 VLBI sessions; all of them contain Wettzell (as a reference station) and Ny-Alesund. Evolution of three components is shown on fig. 5-7. Rate estimates of the components are in Table 2. The latitude drift is a good agreement with NNR-NUVEL-1A model. Vertical drift is non-zero and slightly differ from NNR-NUVEL-1A. Longitude component demonstrates significant deviation from model (more than 5 mm/year). Fig. 8 shows a post-fit residuals for the component. Obviously, it undergoes a slow variations. To check the suggestion all points on fig. 8 have been divided into two subsets (before and after epoch 1996.5) and two independent rates have been estimated (8.4 +/- 5.4 and 18.3 +/- 3.1 mm/year, correspondingly). The latter rate is almost in two times more than the one predicted by NNR-NUVEL-1A. Probably, any deformations at the Svalbard archipelago caused the changes in rates of longitude component motion. It is an active tectonic region near boundary of Eurasian plate. Therefore Ny-Alesund VLBI site tectonic motion can be an indicator of tectonic processes at the region.

Component	Rate and 3σ error from OCCAM (mm/year)	Rate from NNR-NUVEL-1A (mm/year)
Vertical	4.4 +/- 3.3	0.0
Latitude	12.8 +/- 1.5	13.7
Longitude	15.5 +/- 1.7	10.2

Table 2.
Rates for evolution of Ny-Alesund VLBI station components

5. Conclusion

Using the VLBI observations from European network it is possible to get extremely accurate results for VLBI site velocities. The estimates do not depend on choice of software system or observational network. But it is shown the shift due to tectonic motion sometimes can not be approximated by straight line. Variations of the motion sometimes are significant even for short time scale. At least three Italian stations and Ny-Alesund show the effect. All of them are located in unstable tectonic regions. Rather than to consider the site motion as a linear function more flexible model to be developed for purpose of comprehensive ITRF making up.

It is known that results obtained by different techniques on short time scales without mutual temporal overlapping show significant disagreement in rates [see, for example, VLBI and GPS results; Bianco et al., 1997]. The disagreement usually is explained by artifacts following from differences in each technique performance. However, real temporal variations of rates will be able to cause the same picture if there is no a data span overlapping.

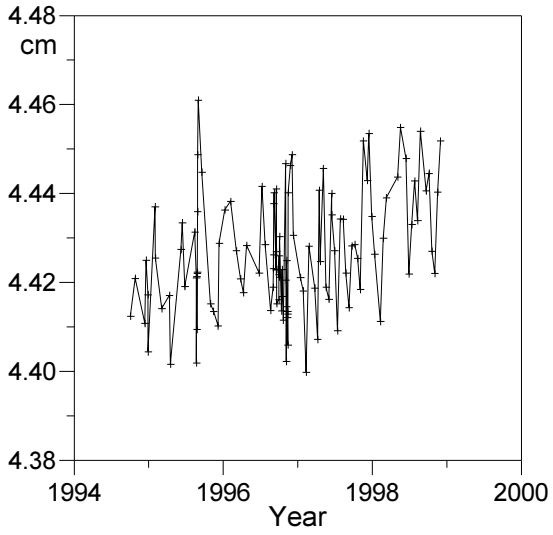

Fig.5
NY-ALESUND radial component

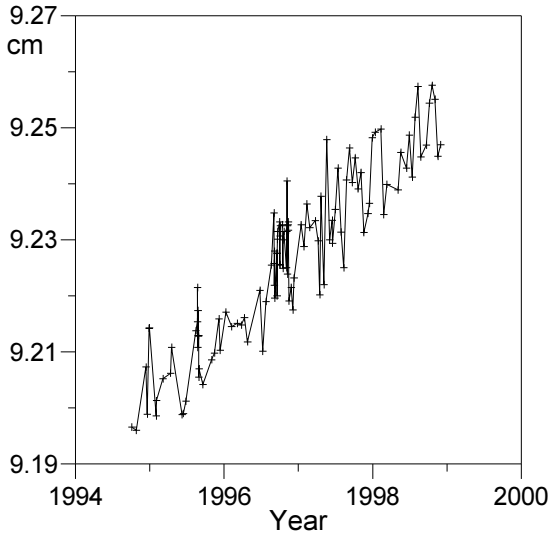

Fig. 6
NY-ALESUND latitude component

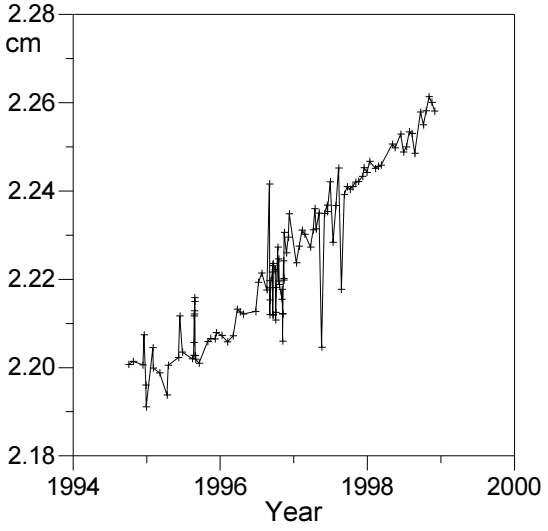

Fig.7
NY-ALESUND longitude component

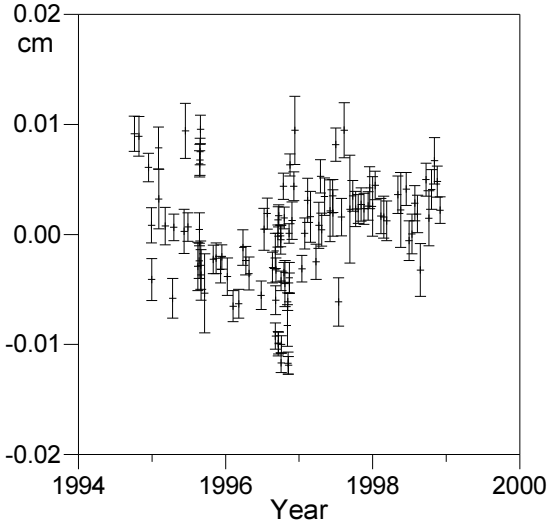

Fig.8
Post-fit residuals of
NY-ALESUND longitude component.
Linear trend and outliers were removed.
Standard deviations of points are shown.

6. References

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