Analysis of VLBI data with different stochastic models

Nataliya Zubko[1], Markku Poutanen[1], Johannes Boehm[2], Tobias Nilsson[2]
[1]Finnish Geodetic Institute
[2]Vienna University of Technology

Introduction

The VLBI observations are generally analyzed using least-squares method. For accurate results the functional and stochastic models need to be well defined. In the standard stochastic model the variance- covariance matrix is dependent on only one stochastic parameter, describing by common level of variance. The analysis of observations can be improved by taking into account additional parameters in the stochastic model, such as the station and elevation angle dependent effects. Thus the model becomes reliant on several stochastic properties. A stochastic model, which includes station and elevation angle dependence of observations, has been implemented in VieVS software[1]. We present results of a comparative analysis using traditional and advanced stochastic models[2]. In advanced stochastic model the variance components of VLBI observations were estimated with the MINQUE method[3].

Stochastic models

In order to estimate unknown parameters we use Gauss-Markoff model with two different stochastic properties. In the first adjustment the covariance matrix was chosen as:

$$\mathrm{D(y)} = \sigma^2 \mathrm{Q} = \sigma^2 \mathrm{P}^{-1} \tag{1}$$

where σ is a factor describing the variance level of the observations, Q and P are the cofactor and the weight matrices correspondingly. The variance factor is estimated with:

$$\hat{\sigma}^2 = \frac{\hat{e}' P \hat{e}}{n-u} \tag{2}$$

In the second adjustment the covariance matrix takes form as follows:

$$\mathrm{D(y)} = \sum_{m=1}^{k} \sigma_m^2 V_m \tag{3}$$

where σ_m (m=1,…,k) are variance components and V_m (m=1,…,k) are accompany matrices. The variance components we estimate with Minimum Norm Quadratic Unbiased Estimation (MINQUE). In our model we estimate the common level of variance, the additive variance, station dependent variances and antenna elevation dependent variances. Estimation of the variances requires 5-15 iterations.

Results

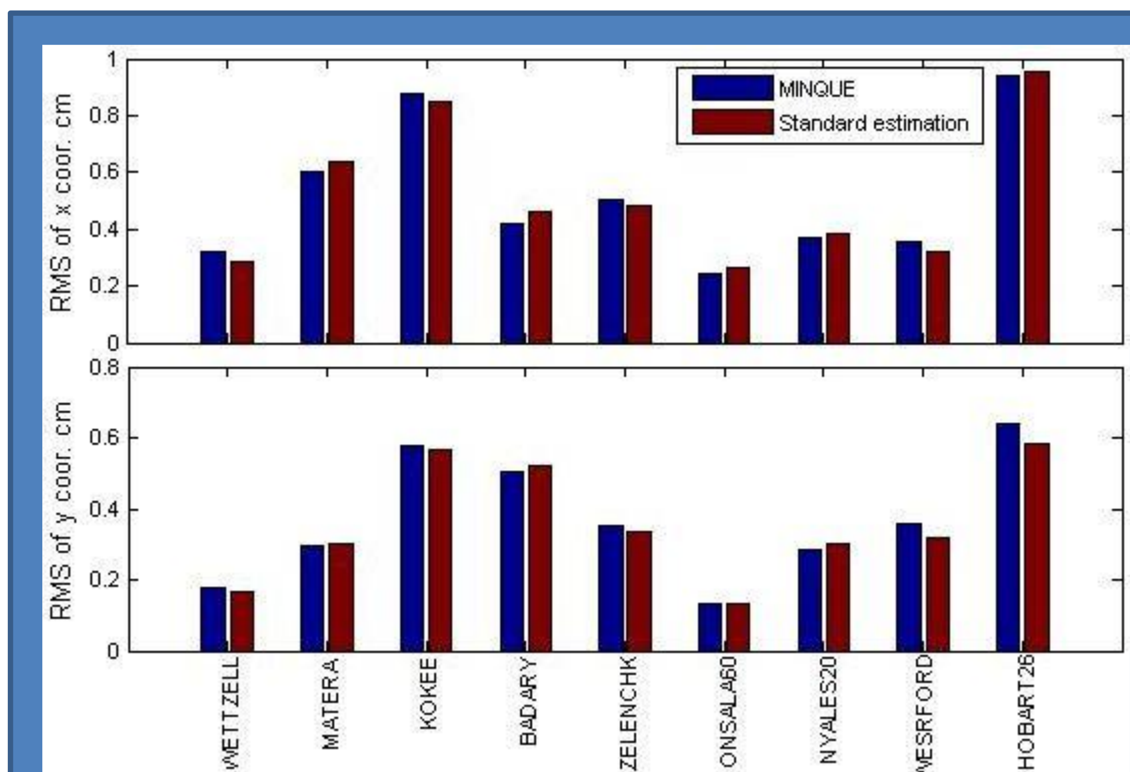

Fig.1 Repeatability of coordinates

Fig. 1 presents repeatability of the X and Y coordinates of a few antennas, estimated using the two stochastic models.

Fig.2 shows residuals of polar motion xpol and ypol coordinates estimated with two stochastic models.

The table contains mean values of estimated variances with iterative MINQUE method. Variances in such estimation can take negative value, however the covariance matrix (3) must be positive.

The analysis includes data of 50 observed sessions.

Type of variance	Mean value	Standard deviation
Common	0.5656	0.3755
Additive	0.3728	0.2074
Wettzell	0.4789	0.4839
Matera	0.3497	0.718
Kokee	0.651	0.6807
Badary	0.7398	0.6957
Zelenchk	1.016	0.8325
Onsala60	0.4645	0.5739
Nyales20	0.03644	0.379
Westford	0.4498	0.4761
Hobart26	1.577	1.592
El. angle=5°-8°	0.6513	0.9669
El. angle=8°-11°	0.4773	0.6352
El. angle=11°-15°	0.3354	0.6252
El. angle=15°-20°	0.1962	0.4834
El. angle=20°-30°	0.01549	0.4829
El. angle=30°-45°	0.004851	0.3911
El. angle=45°-65°	-0.03137	0.4461

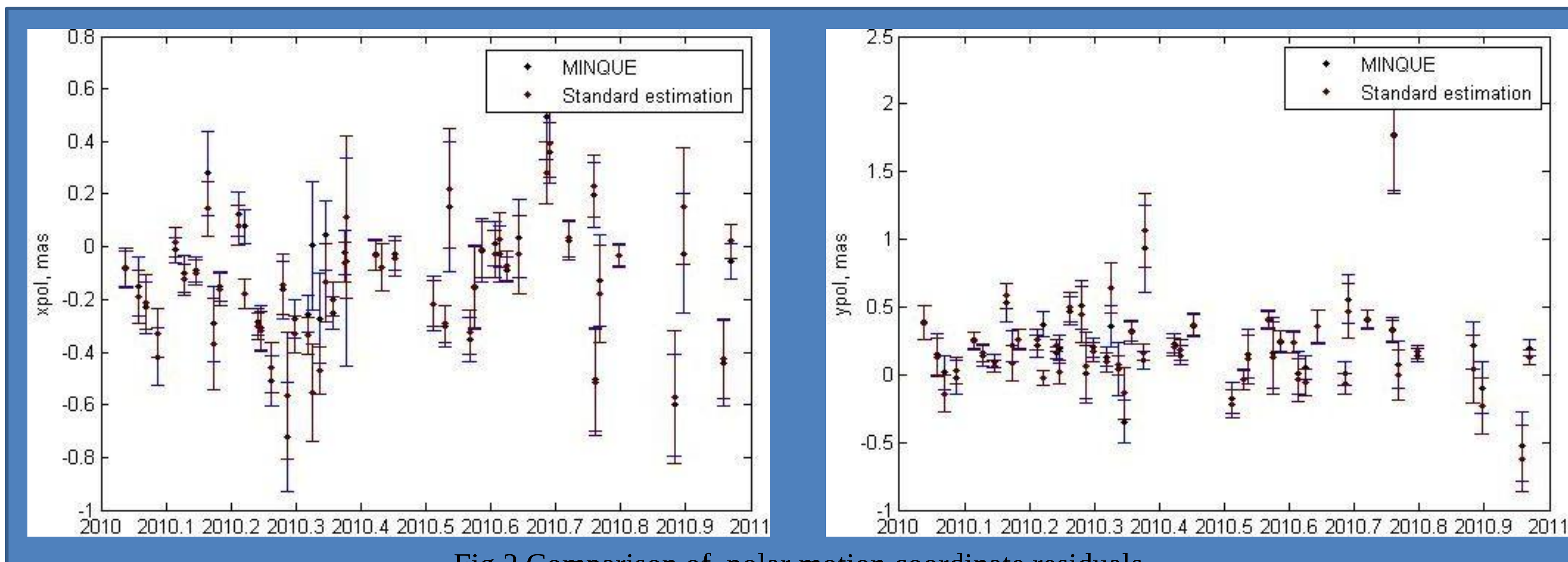

Fig.2 Comparison of polar motion coordinate residuals

References:

1. J. Boehm, H. Spicakova, L. Plank, K. Teke, A. Pany, J. Wresnik, S. Englich, T. Nilsson, H. Schuh, T. Hobiger, R. Ichikawa, Y. Koyama, T. Gotoh, T. Kubooka, and T. Otsubo. Plans for the Vienna VLBI Software VieVS. Proceedings of the 19th European VLBI for Geodesy and Astrometry Working Meeting, edited by G. Bourda, P. Charlot, and A. Collioud, Bordeaux, pages 161–164, 2009.
2. V. Tesmer, Refinement of the stochastic VLBI model:first results. . Proceedings of the 16th European VLBI for Geodesy and Astrometry Working Meeting, pages 207-218, 2003.
3. C. Rao, Linear statistical inference and its applications. Verlag John Wiley & Sons, New York, London, 1973.