On dependence of EOP precision and accuracy on VLBI network

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Abstract. In this paper, a new VLBI network geometry index, the volume of network, is examined as an indicator of the quality of the Earth rotation parameters (EOP) obtained from VLBI observations. It has been shown that both EOP precision and accuracy can be described by a power low $\sigma = aV^b$, where V is the volume of network, in a wide range of the network size from domestic to global VLBI networks. In particular, the dependence found in this study can be used for comparison of results obtained from different observing programs.

Keywords. VLBI, Earth Rotation Parameters, EOP precision, EOP accuracy, network geometry

1 Introduction

By the nature of the VLBI technique, the quality of the Earth rotation parameters (EOP) derived from the VLBI observations depends on network geometry that is its size and orientation. We can consider some network geometry indices, such as

- Network span: $(\Delta\varphi,\ \Delta\lambda)$, $(\Delta X, \Delta Y, \Delta Z)$.
- Network orientation: mean longitude, baselines directions.
- Number of stations.

Defining and quantification of dependence of the EOP precision and accuracy on network geometry is important for practical purposes, *e.g.* planning of VLBI network or comparison of EOP results obtained from different networks and observing programs. In the common case, such dependence can be expressed as a function of several network geometry indices. In this study we consider a new generalized index of VLBI network geometry, namely the volume of network, which allows us to find the dependence of the EOP quality on network geometry good enough for practical use. It was shown that both EOP precision and accuracy strongly follow to a power low w.r.t. the network volume.

Table 1. Volume of different VLBI networks. Smallest, largest and two latest CONT campaigns networks are shown.

Session	Volume, Mm^3
JD0610	9.925E-04
EURO35	5.285E-03
JD0610	5.285E-03
EURO56	1.761E-02
CONT02	9.221E+01
CONT05	2.654E+02
T2037	4.607E+02
T2038	4.723E+02
T2041	4.816E+02
T2043	4.871E+02

2 Dependence of the EOP quality on the network volume

We have computed the volume of network in the following way.

1. Compute the tetrahedron mesh for the network polyhedron by means of the Delaunay triangulation making use of the GEOMPACK package by B. Joe (Joe, 1991).
2. Compute the volume of each tetrahedron as scalar triple product: $[(\vec{r_2} - \vec{r_1})(\vec{r_3} - \vec{r_1})(\vec{r_4} - \vec{r_1})]$.
3. Compute the sum of volumes of the tetrahedrons.

Some examples of the volume of different IVS observing networks are shown in Table 1. For comparison, the volume of the Earth is 1083 Mm^3.

Table 2. Representation of the EOP precision by a power low $\log\sigma = a + b\,\log V$.

EOP	a	b
Xp	-0.340 ± 0.022	-0.351 ± 0.018
Yp	-0.342 ± 0.023	-0.373 ± 0.019
UT	-0.603 ± 0.043	-0.382 ± 0.036
Xc	-0.771 ± 0.016	-0.238 ± 0.013
Yc	-0.772 ± 0.016	-0.238 ± 0.013

Table 3. Representation of the EOP accuracy by a power low $\log\sigma = a + b\,\log V$.

EOP	a	b
Xp	-0.212 ± 0.045	-0.315 ± 0.038
Yp	-0.263 ± 0.049	-0.298 ± 0.041

We have performed the following computations for this study.

1. Compute EOP for all 24h sessions starting from 1996.5, which corresponds to the beginning of the IGS series used for further comparison.

2. Split EOP results into bins by the network volume V: $V<0.1$, $(\sqrt{10})^k \le V < (\sqrt{10})^{k+1}$, $k = -2, \ldots, 5$.

3. Compute for each bin:

   - average network volume,
   - average EOP uncertainty,
   - WRMS of the differences between the VLBI and IGS EOP series igs95p02.erp after removing trend (for pole coordinates only).

Then we have computed the parameters of the power low representing the dependence of the VLBI EOP precision (uncertainty) and accuracy (WRMS w.r.t. IGS) as $\log\sigma = a + b\,\log V$, where σ is the error value under consideration (uncertainty or WRMS for given type of EOP). Parameters a and b were computed by means of the least square linear fit with weighting dependent on number of sessions fallen into each bin. Results are presented in Fig. 1, 2 and Tables 2, 3. In the plots and tables Xp and Yp denote the terrestrial pole coordinates, and Xc and Yc denote celestial pole offset. One can see that the dependence of both EOP precision and accuracy is nicely described by a power low.

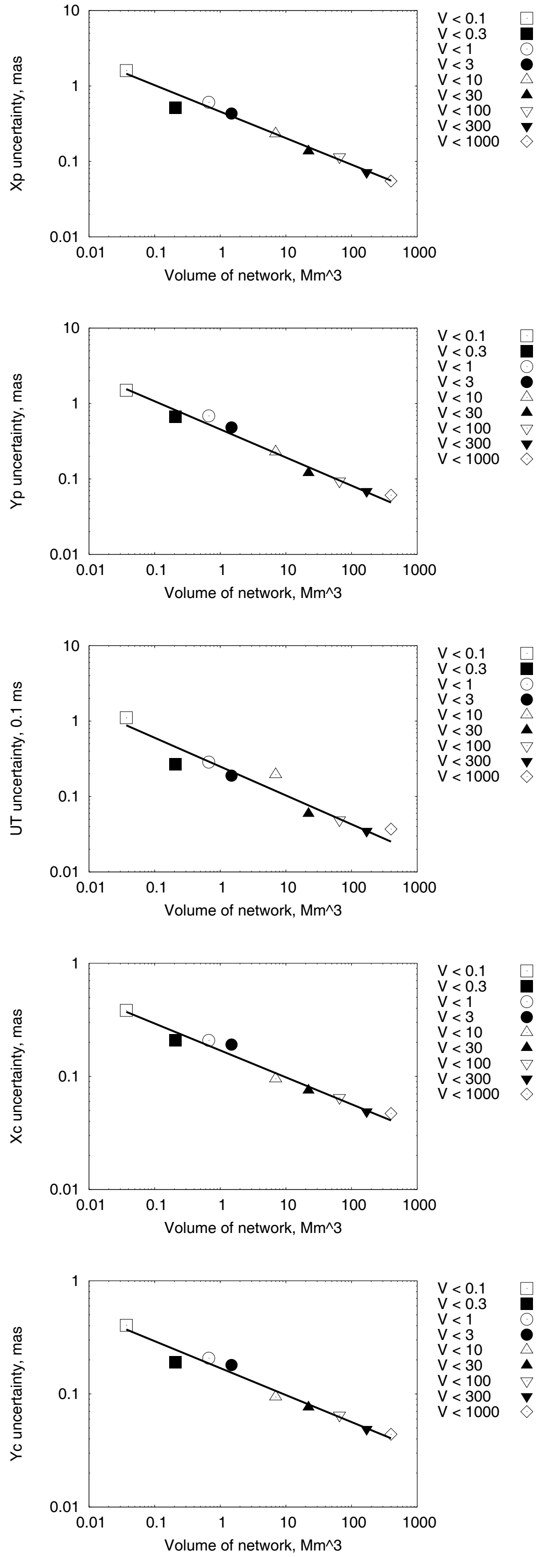

Figure 1. Dependence of the EOP precision on the network volume V. Solid line corresponds to the power low (Table 2).

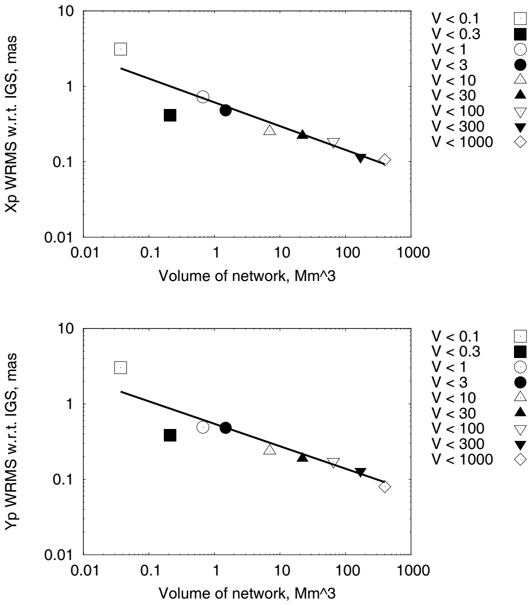

Figure 2. Dependence of EOP accuracy on the network volume V. Solid line corresponds to the power low (Table 3).

3 Comparison of observing programs

As an example of application of proposed method of estimation of the EOP quality depending on network geometry, we considered a comparison of EOP results obtained from different IVS observing programs. For this purpose, we have performed the same computations as described in the previous section, with only difference that EOP results were split into 13 observing programs: global networks R1, R4, RD, RDV, NEOS-A, CORE-A, CORE-B, CONT02, CONT05, T2, E3, and regional networks EURO, JADE. Results of computations are presented in Fig. 3 and 4. Solid lines on these plots correspond to the power low with parameters found above (Tables 2 and 3 for EOP precision and accuracy correspondingly).

Comparing results with ones obtained in the previous section, one can see that the scatter of the points in Fig. 3 and 4 is greater than one in Fig. 1, 2, which can be explained by the fact that, as a rule, networks of different size participated in the same observing program. It can be seen that scatter of EOP accuracy (Fig. 4) is much less than that of EOP precision (Fig. 3). This means that EOP accuracy follows more strongly to a power low than EOP precision.

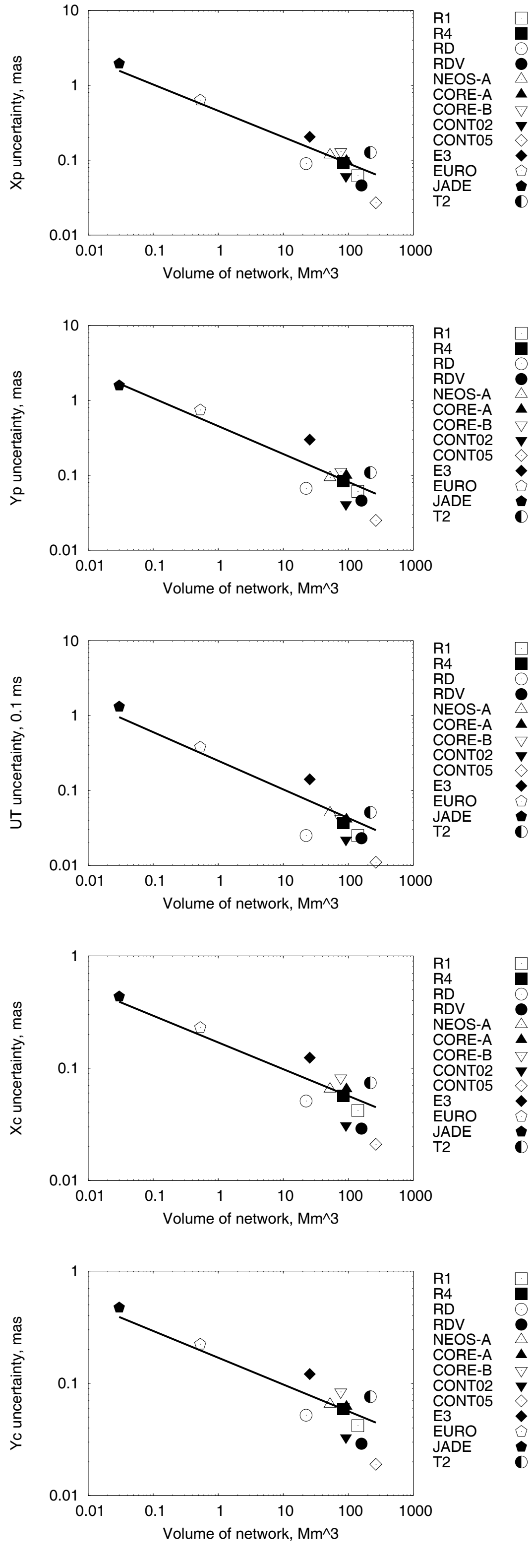

Figure 3. Dependence of the EOP precision on the network volume V for different observing programs. Solid line corresponds to the power low (Table 2).

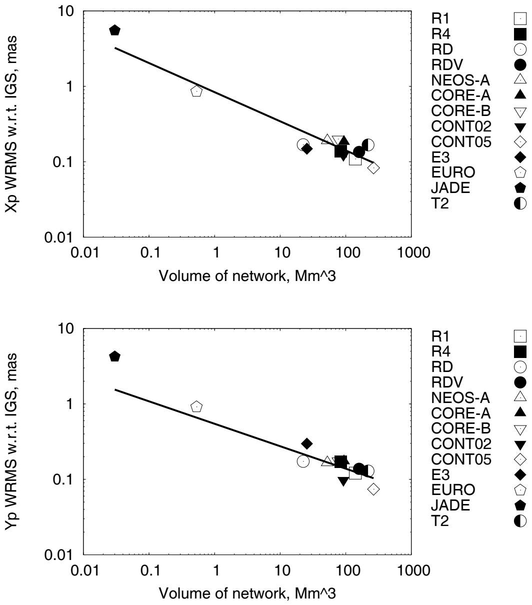

Figure 4. Dependence of the EOP accuracy on the network volume V for different observing programs. Solid line corresponds to the power low (Table 3).

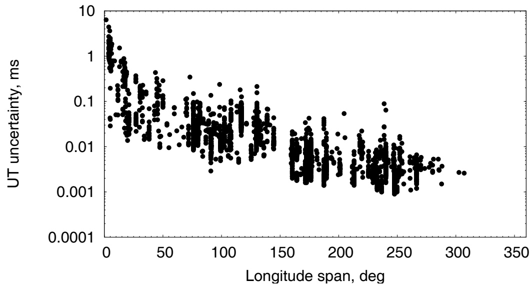

Figure 5. Dependence of the UT1 uncertainty on the longitude span.

Plots in Fig. 3 and 4 reveal some other interesting features, for instance:

- Somewhat better precision and accuracy of R1 program as compared with R4 may be a consequence of the difference in network size ($V_{mean}^{R1} = 140$ Mm^3, $V_{mean}^{R4} = 84$ Mm^3).

- E3 program observed with relatively small number of stations and low data rate shows relatively low precision but good accuracy at a level of Mk4 observations.

- Difference in the EOP quality of RD and R1 programs actively discussed by the IVS Observing Program Committee[1] also can be explained by large difference in the network volume ($V_{mean}^{RD} = 22$ Mm^3). From the plots, we can conclude that R4 program provides better EOP precision and accuracy than R1 after correction for this factor.

4 Conclusions

The volume of VLBI network can serve as a generalized index of network geometry. It allows us to get an effective estimate of both precision and accuracy of EOP for both global and regional networks in wide range of network size and schedule parameters. The dependence of the EOP quality on the network volume found in this study can be used for comparison EOP results obtained from different networks and observing programs. It also can be used in planning of new VLBI networks.

Indeed, this method is applicable only to VLBI networks consisting of at least four stations. For 3-station network, it worth testing the area of the triangle as an index of network geometry.

We consider the method described in this paper as a convenient and accurate enough tool for investigation and prediction of the quality of EOP obtained from different VLBI network. Other dependencies can be used for specific purposes, *e.g.* dependence of UT1 results on longitude span (see Fig. 5).

It should be mentioned that the main conclusion drawn from this study is that EOP precision and accuracy obtained from VLBI observations can be well described by a power low w.r.t. the network volume. However, specific numbers shown in Tables 2, 3 may vary depending on the software used for analysis. For this reason, deriving of the power low parameters and further applications should be made making use of the same software and processing options.

[1] http://ivscc.gsfc.nasa.gov/pipermail/ivs-opc/2007/

References

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