Reference epochs in VLBI estimations of clock parameters

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Question: Do the results of the VLBI parameter estimation change if we select the mean epoch instead of the beginning of the session for the clock offset parameters?

Background

In most analysis packages, the reference epoch of the relative clock offsets has always been the start of the sessions. If we consider a simple first order model for the relative clock parameters, i.e., just an offset and a rate, the formal errors of the regression parameters improve if the reference epoch is chosen to be at the middle of the session. In Altamimi et al. 2002, this is called the epoch of minimum variance.

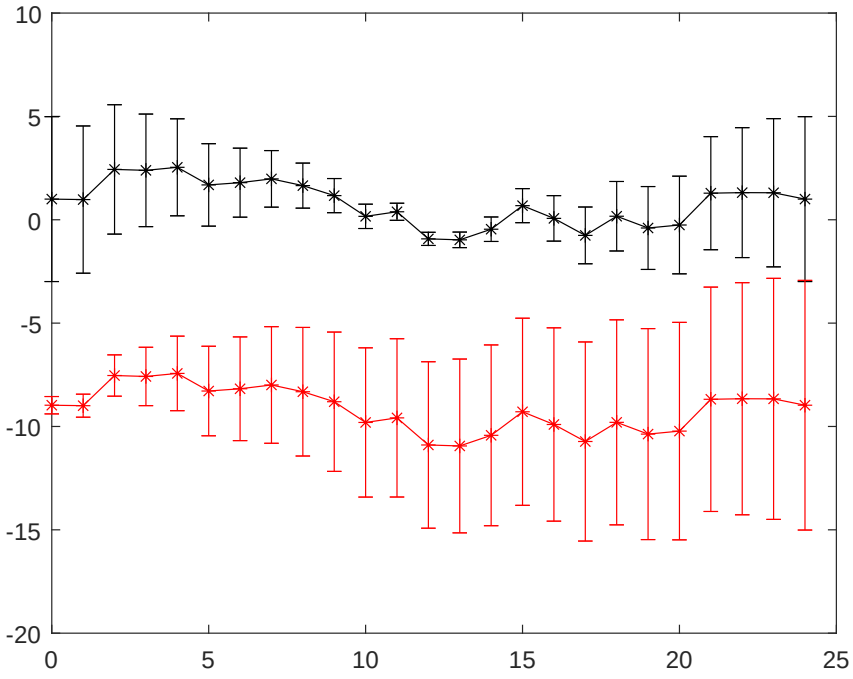

Figure 1: Estimates [cm] of clock piece-wise linear polygons for OV-VLBA in session 17NOV28XA.
1 cm $\hat{=}$ 33 ps. Units of x axis are hours since the session start.
Bottom = Reference epoch at beginning of session, Top = reference epoch at middle of session.

Analysis

In a small study we have investigated whether this fact could be exploited in VLBI data analysis. For the CONT17a series of sessions, we ran solutions with the reference epochs of the clocks being the middle of the session and compared the results to those of standard solutions. The clock parameterization for all stations except of a reference station consists of a second order clock polynomial plus piece-wise linear segments of 1 hour duration represented as a clock offset polygon. Zenith wet delays and gradients, all EOP, station coordinate offsets constraint by NNR/NNT conditions and source position offsets constraint by NNR conditions are the other parameters.

Results

We found that for simple clock polynomials as well as for any standard parameterizations of the clocks, e.g., with polynomials and piece-wise linear polygons, the absolute values of the offsets changed but not the values of the other parameters. For the piece-wise linear polygons, the differences changed in the form of a constant bias for every epoch.

The most noticeable effect is that the formal errors of all clock offset parameters do improve significantly (See example Fig. 1). We see that the monotonous deterioration of the formal errors is restricted by the reference epoch lying in the middle of the session. Significant improvements also apply to the formal errors of all clock rates but not to those of the quadratic terms which remain unchanged.

For the changes in the correlation matrices, we show this for session 17NOV28XA as an example as well (Fig. 2). The first 297 parameters in the list are the clock parameters. We see station-wise block-diagonal patterns for the 273 clock offsets and distinct changes between the clock offsets and the 24 rate and quadratic terms of the clock functions. On the other hand there is a number of very small changes in the correlations of the clock offset parameters with other parameters (see also zoomed graph Fig. 3). Within the block of non-clock parameters, no changes are discernible at all. The changes in the correlations do not affect the formal errors of these other parameters beyond some small numerical differences.

Although the correlation matrices change, there, unfortunately, is no improvement for the formal errors of any other, non-clock parameter.

We also looked at the condition numbers of the normal matrices but did not find any significant effects either.

Conclusions

Except of the fact that the formal errors of the clock offsets improve considerably, we did not find any evidence that the selection of the reference epoch for the clock offset estimates can improve VLBI solutions in general. We conclude that the effects of changing the reference epoch are confined to the clock offset and rate parameters alone.

Reference

Altamimi Z, Sillard P, Boucher C (2002) ITRF2000: A new release of the International Terrestrial Reference Frame for earth science applications. JGR, 107:B10, 2214, doi:10.1029/2001JB000561

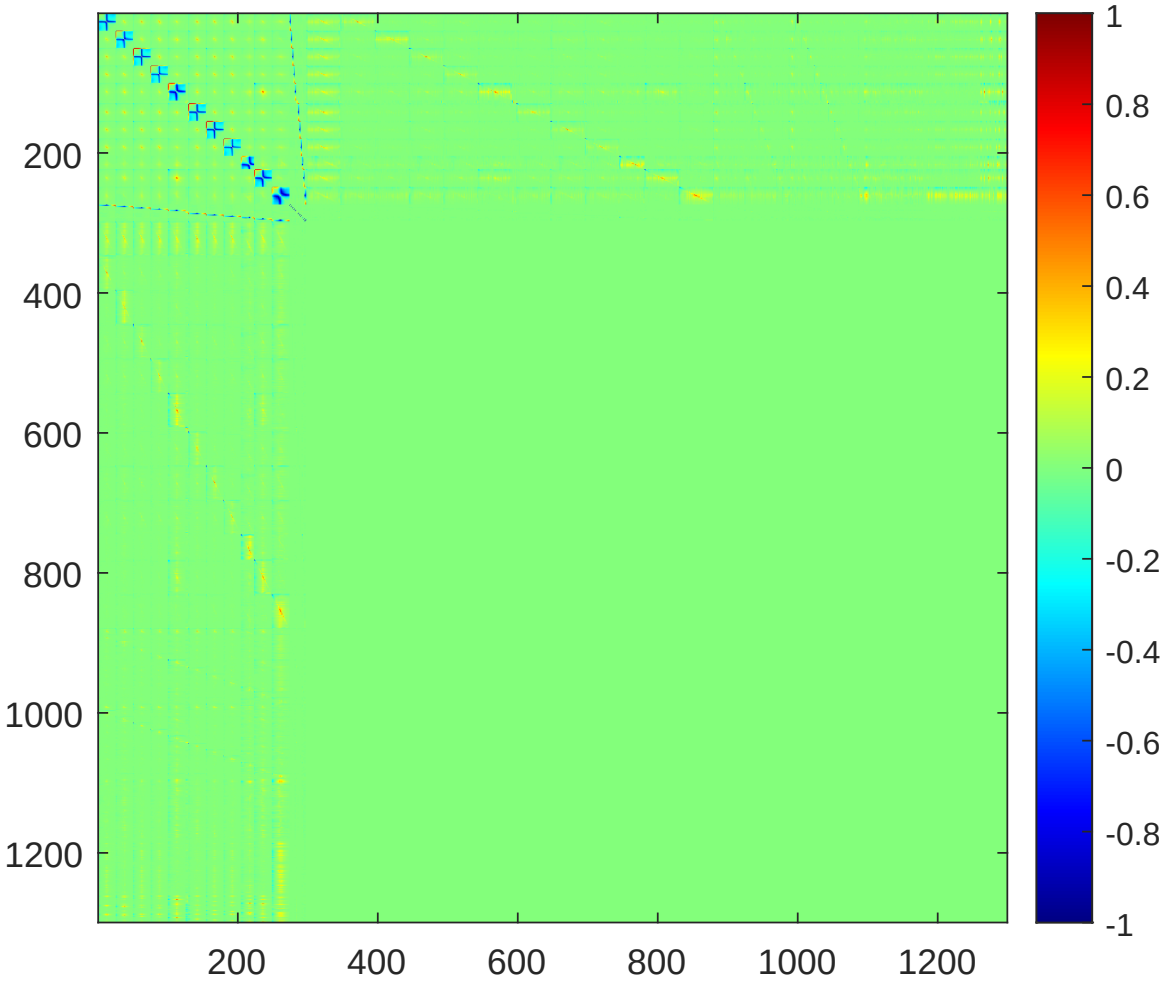

Figure 2: Differences in correlation coefficients in session 17OCT28XA. Order of parameters: 273 clock offsets, 24 rate and quad. terms of clock functions etc.

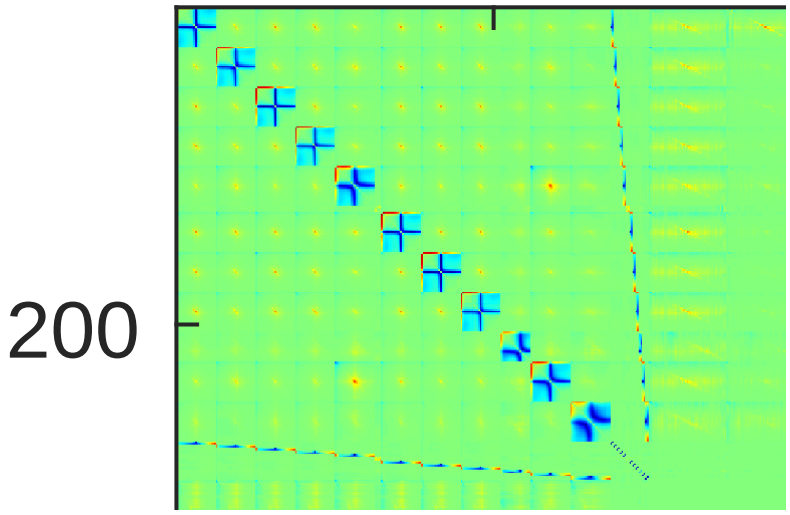

Figure 3: Enlarged excerpt of Fig. 2 (Differences in correlation coefficients).