Seventh VieVS User-Workshop

Discussions on optimized parameterization of VLBI auxiliary parameters in least-squares adjustment of VieVS software

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- This work has been prepared with reference to work performed at Deutsche GeoForschungsZentrum (GFZ)-Potsdam during a research visit July-September 2013.

Tanir Kayikçi E., Heinkelmann R., Karbon M., Nilsson T., Raposo-Pulido V., Soja B. , et al., "Optimized Parameterization of VLBI Auxiliary Parameters in Least-Squares Adjustment: Preliminary Results", International Association of Geodesy Symposia , vol.143, pp.1-7, 2015

WHAT WAS PERFORMED?

- **The study presented and investigated three different approaches for achieving optimum parameterizations of the auxiliary parameters per station for each session.**

- **Optimization ideas presented in the work concentrated on**

  - determining the interval lengths and the optimal size of the constraints of the various auxiliary parameter groups to certain fixed number of observations at each estimation interval per station,
  - considering gaps and the time dependent variation of the parameters over certain interval(s).

- **The impact of the different size of the constraints and the interval lengths for various auxiliary parameter on various VLBI solutions analyzed with the Vienna VLBI Software (VieVS) was assessed by descriptive statistics**

INTRODUCTION

VLBI solutions require

- a considerable number of auxiliary parameters (zenith wet delay (zwd), clock, and north (ngr) and east (egr) gradients) for optimally modeling the atmosphere and clock behavior

Current version of VieVS uses

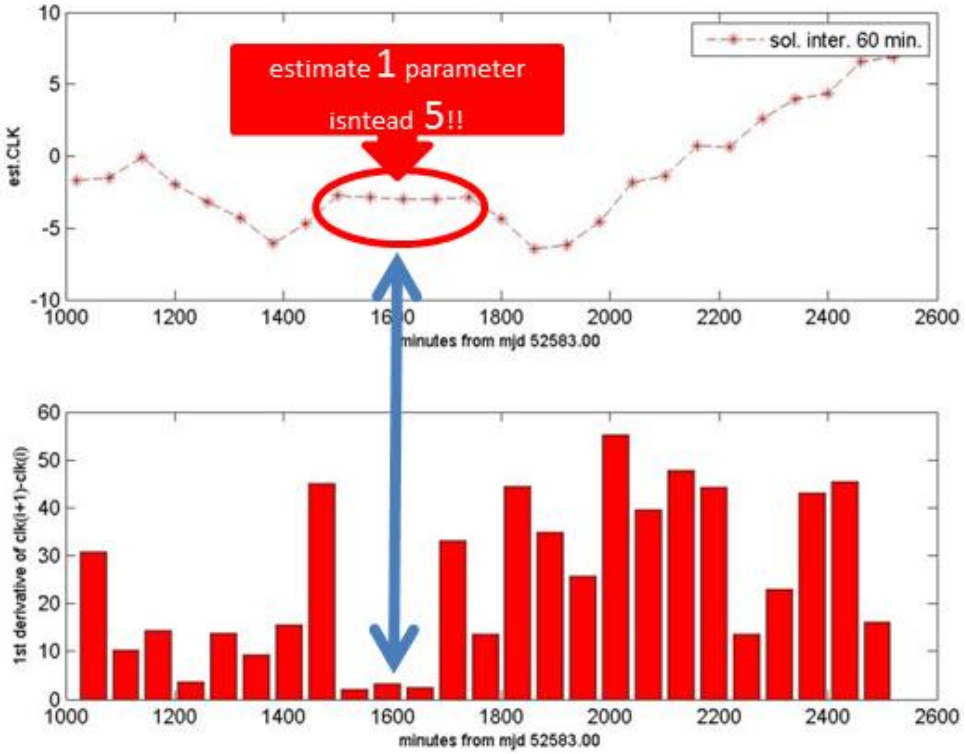
- a piece-wise linear representation of these parameters with a default temporal resolution of 60 minutes

Approach1

Assigning estimation intervals based on time dependent behavior of parameters

- if the time dependent variation of a parameter over certain interval(s) is relatively small, then the estimation interval can be increased.
- if the variation is relatively large, the estimation interval can be decreased to better represent the behavior of this specific parameter.

Time dependent variations of clock estimation of station GILCREEK at Session 02NOV05

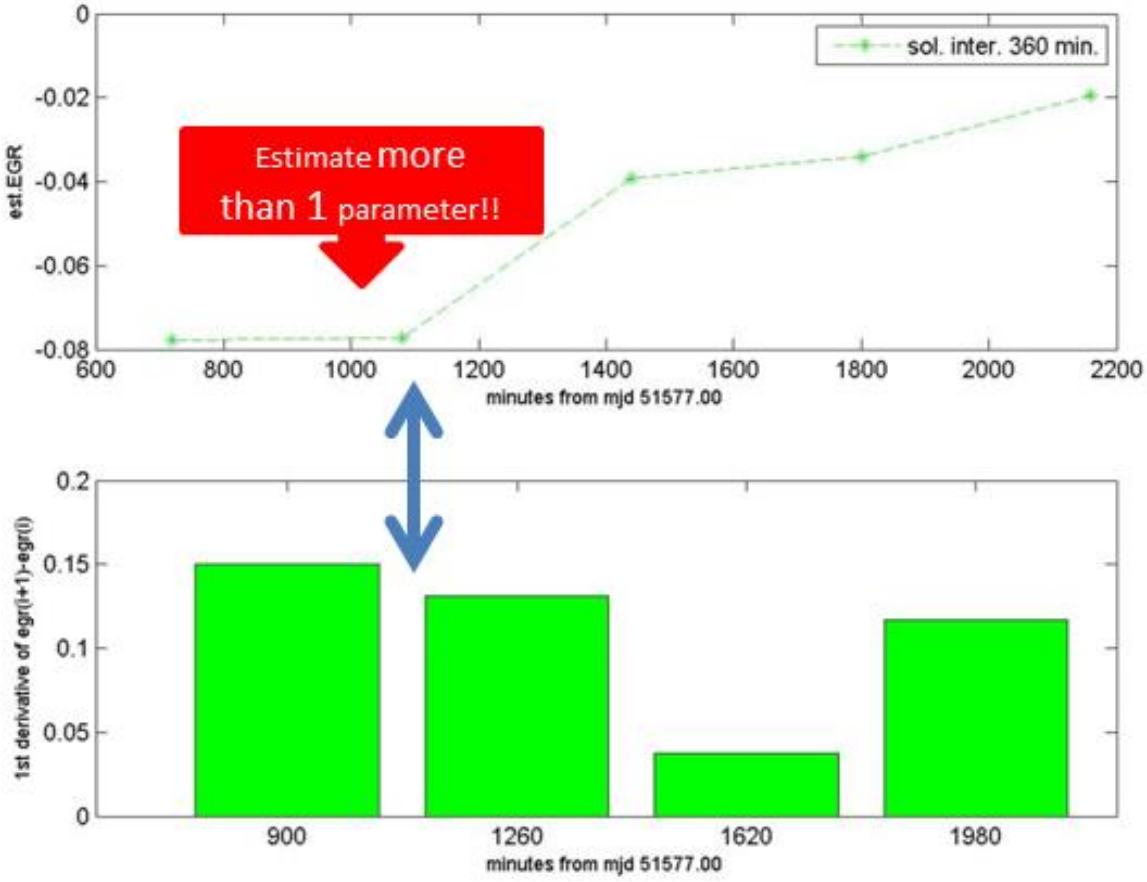


If the temporal variation of a parameter over a certain interval is relatively small, the interval length of the parameter will be increased for the successive estimations.

around minutes 1600 of mjd 52583, five estimated parameters have almost the same values and show relatively small variations in the successive parameter differences

As a consequence of this temporal behavior, only one parameter will be estimated instead of five

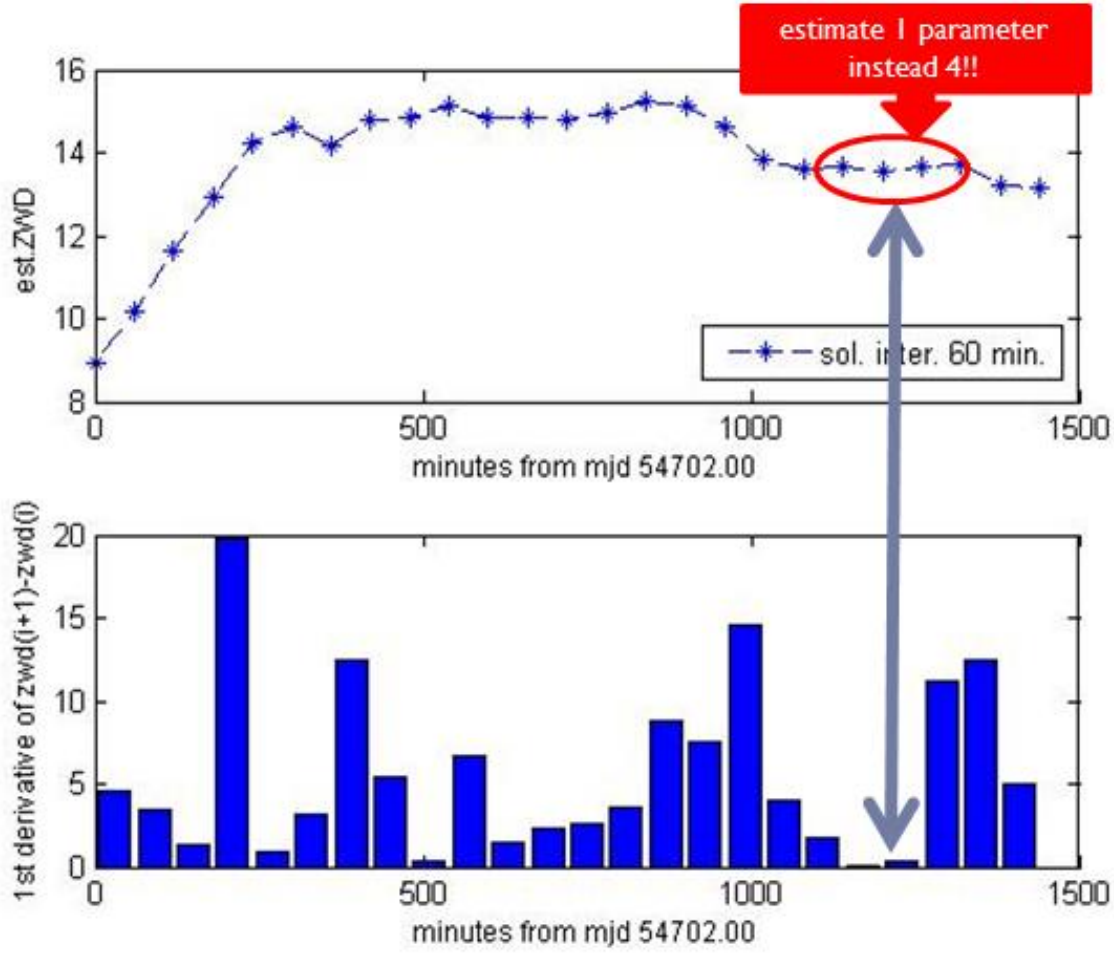
Time dependent variations of ngr estimation of station FORTLEZA at Session 00FEB03



The larger first derivatives of successive differences for the first three parameters are shown; for the interval between minutes 1000 and 1200 of modified Julian date (mjd) 51577 more than one parameter is estimated

if the variation is relatively large, the length of the estimation interval will be shortened.

Time dependent variations of zwd estimation of station SVETLOE at Session 08AUG24 (CONT08)



- Estimating only one parameter increases the redundancy.
- Since, the variations over time are relatively small, the residuals of the observations do not increase significantly.
- The gained redundancy can be utilized to set up more parameters where larger variations were found.
- It is possible to specify estimation intervals of a parameter type according to a first standard solution while keeping the overall number of parameters constant.
- *approach I* should be done iteratively whenever the session is reanalyzed.

This iterative optimization will be investigated in future.

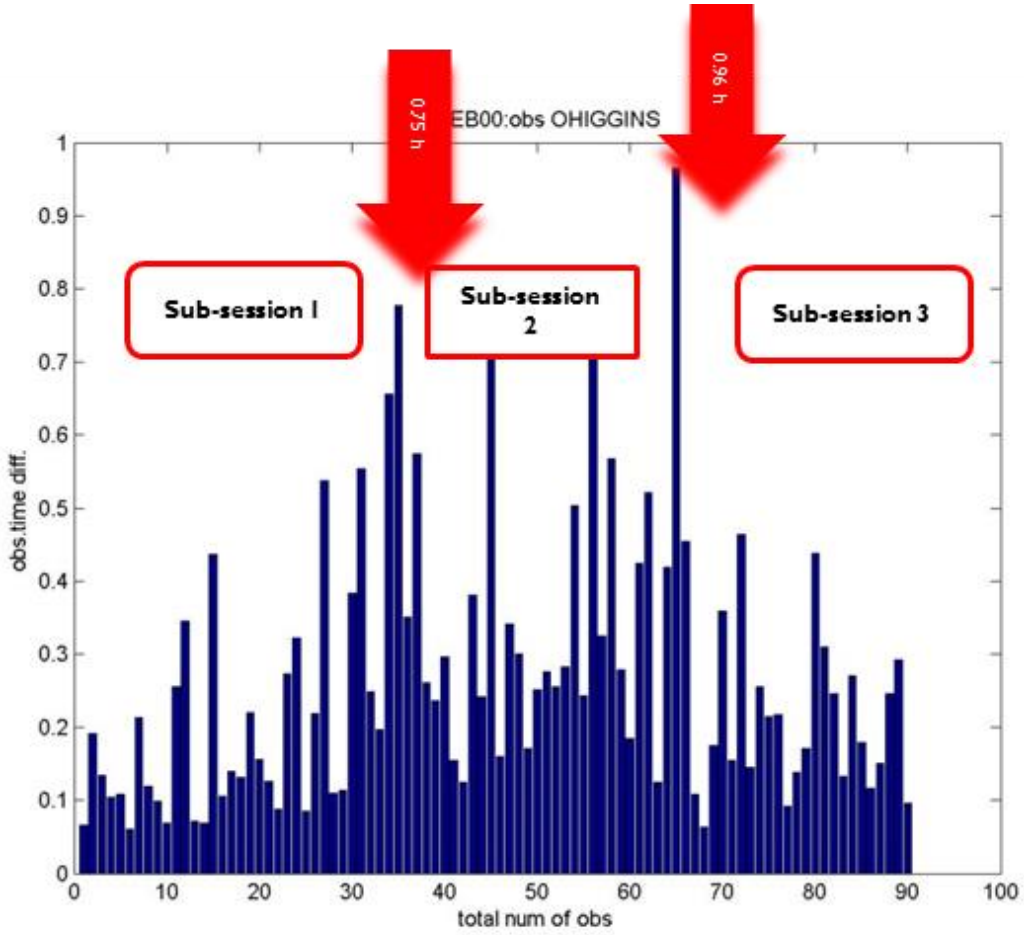
Approach2

Defining no parameter inside a data gap

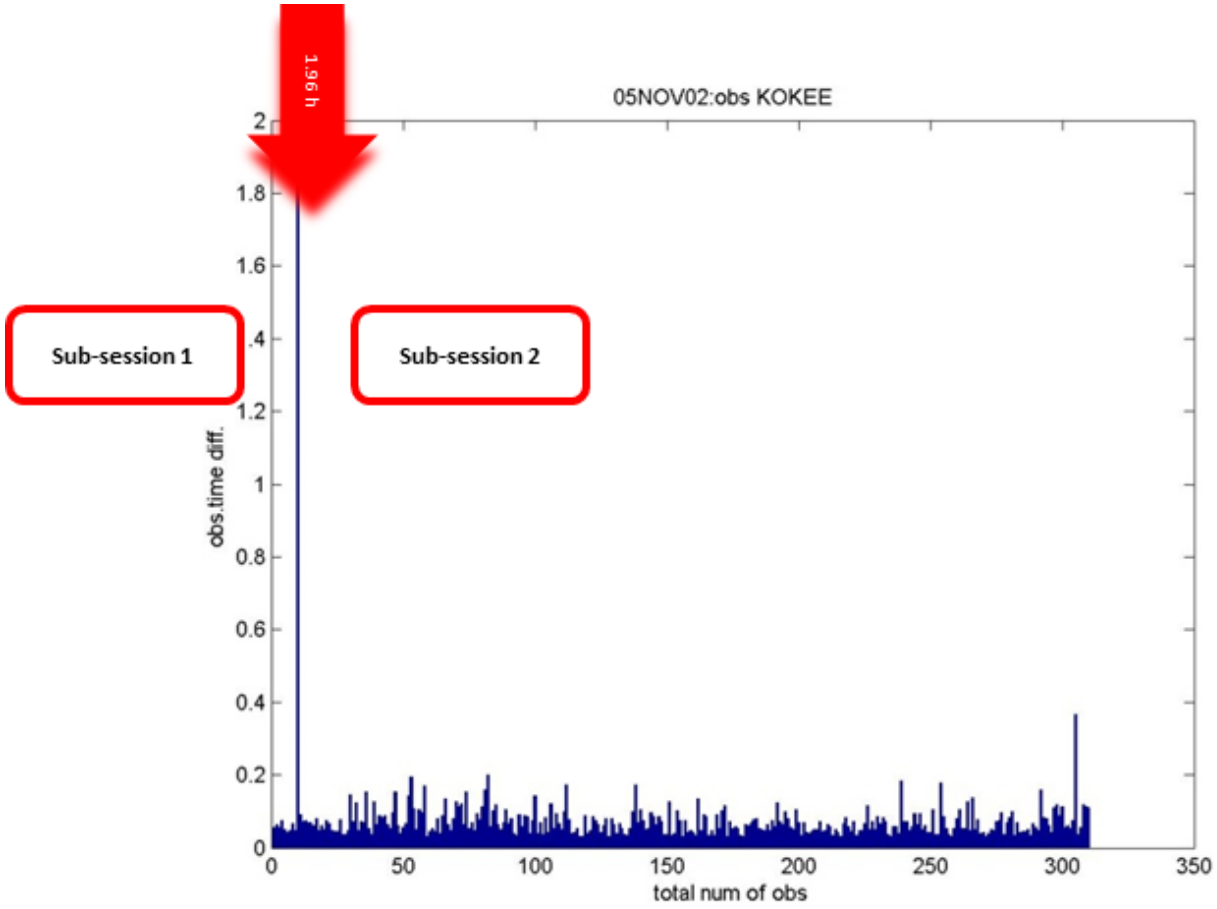
- Such a parameter is only based on the constraint and is likely to degrade the solution (the non-singularity of the equation system is ensured by the constraint).
- In case of a data gap, the method considers the data in two subsets, one before and one after the gap.

time difference of greater or equal 45 minutes between successive observations at a station as a data gap!!

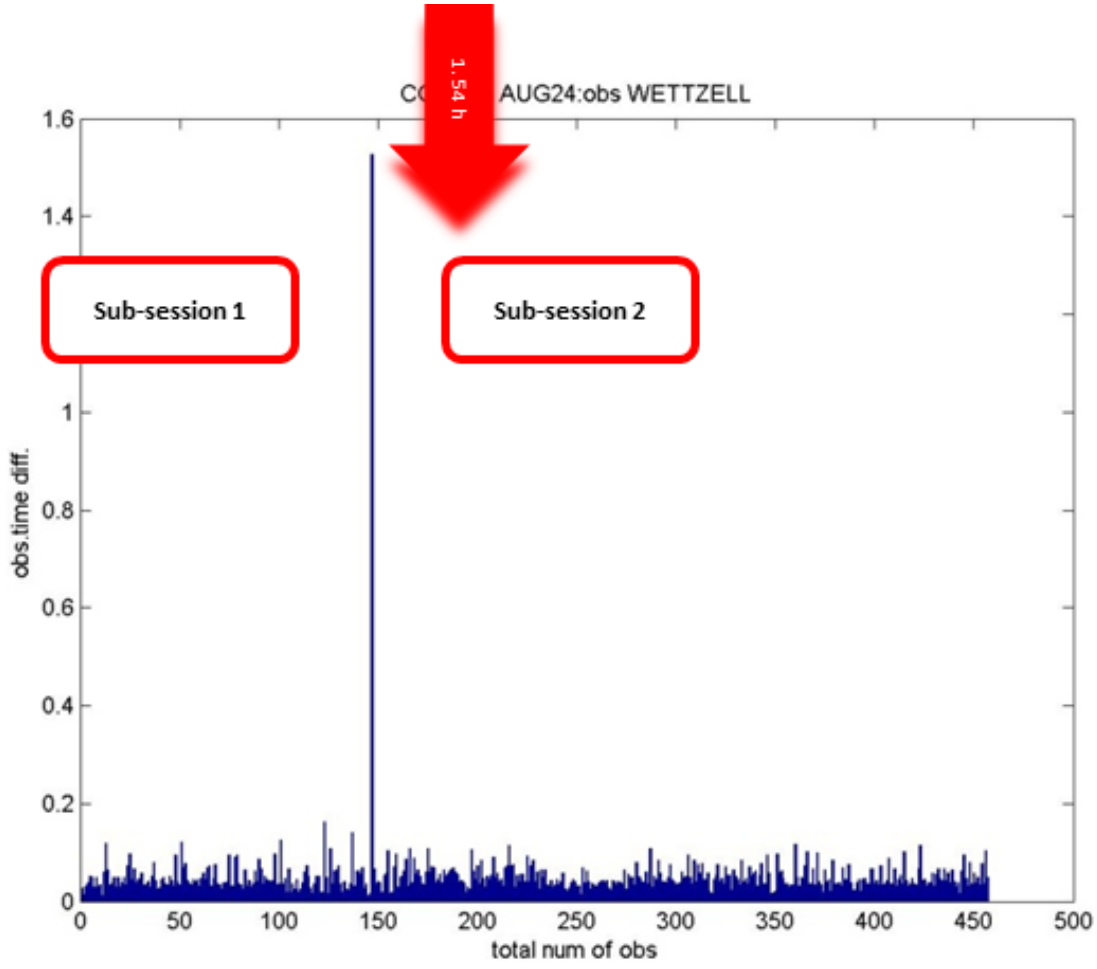
Differences of sequential observation times at station OHIGGINS at Session 00FEB03



Differences of sequential observation times at station KOKEE at Session 02NOV05

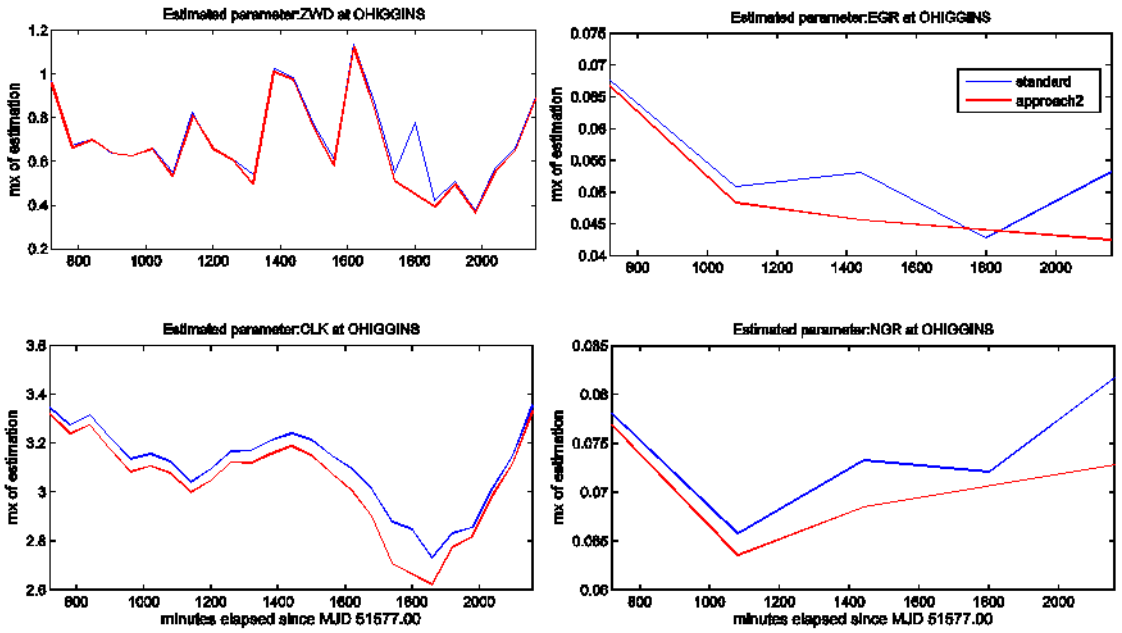


Differences of sequential observation times at station WETTZELL at session 08AUG24 (CONT08)



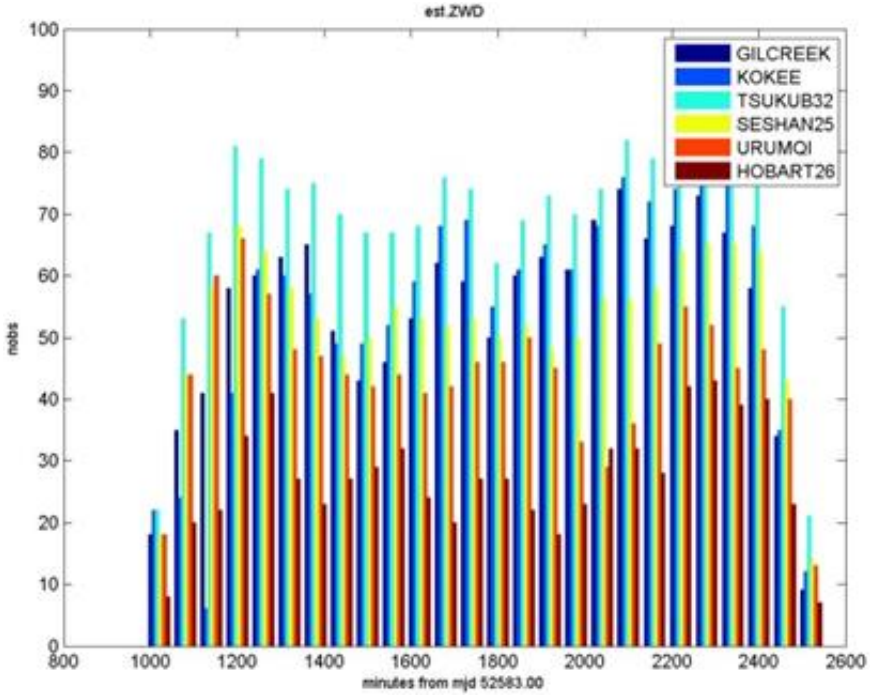
Results of 2. Approach

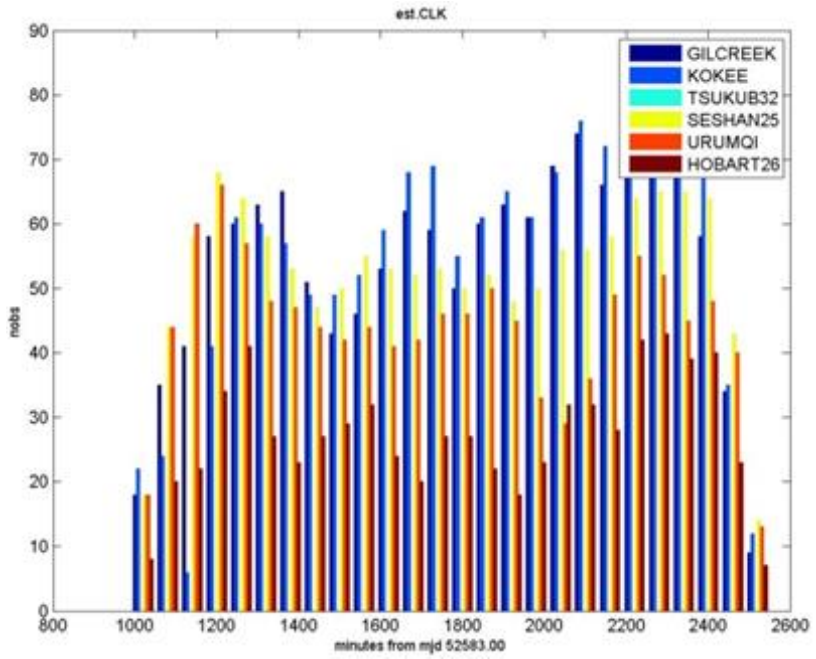
- *approach*2, slightly decreases the resulting formal errors of the auxiliary parameters around the gaps, and the estimated values of parameters with *approach2* agree with the results of the *standard approach* (currently used for the parameterization in the VieVS software providing the standard VLBI least-squares solution) for station OHIGGINS.



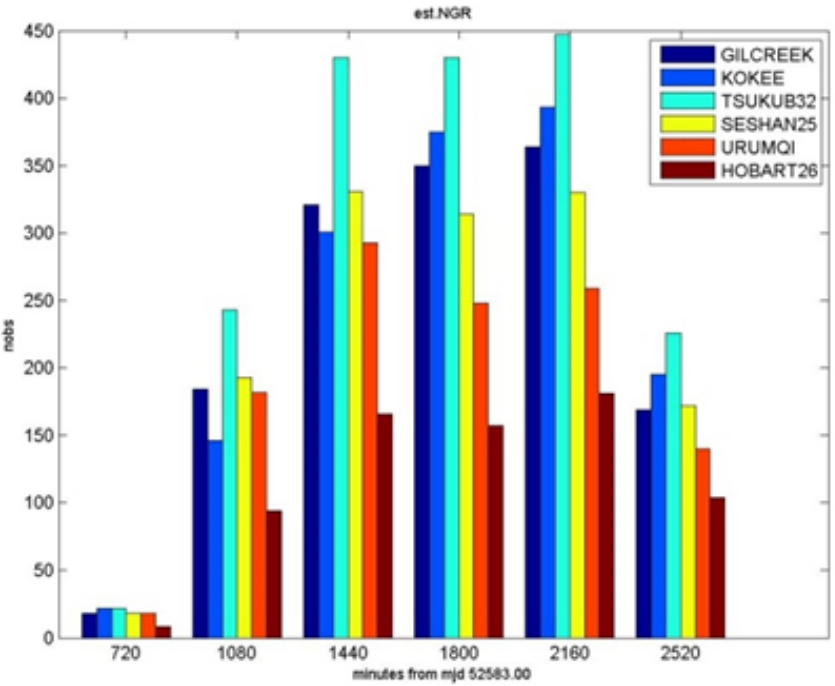
Approach3

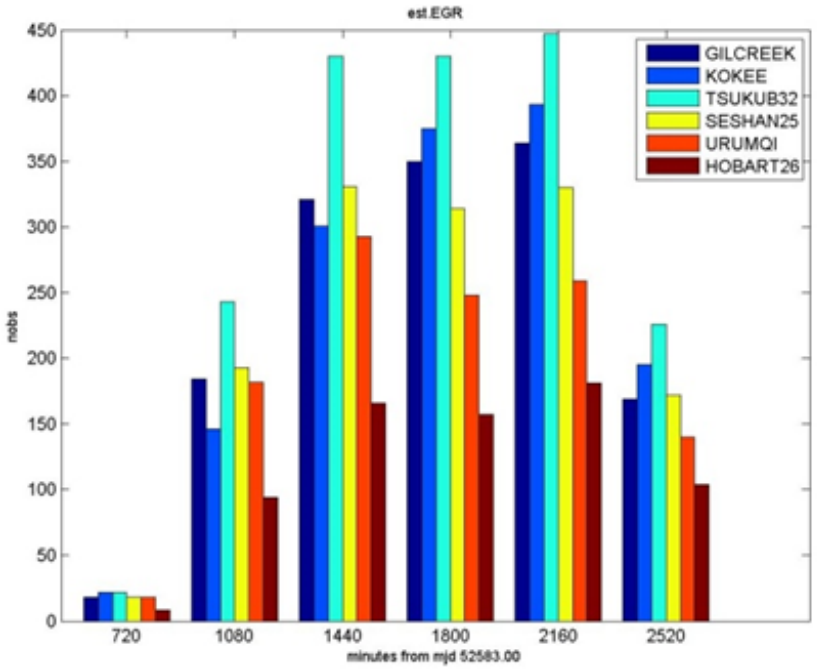
- **Investigates flexible length of time intervals depending on a certain number of observations.**
- **it is possible to obtain an equal partial redundancy for each auxiliary parameter, i.e. each parameter is determined by the same number of observations.**





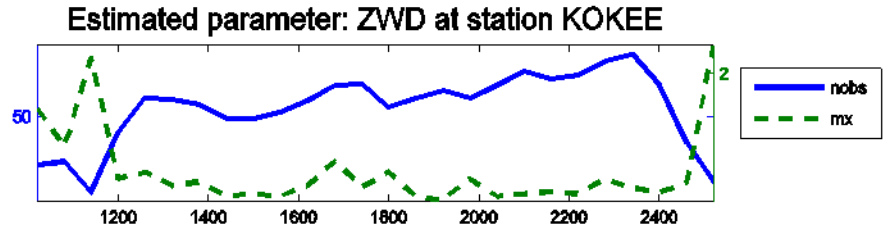
Number of observations used in estimation of zwd (60 min. intervals) and clock (60 min. intervals)

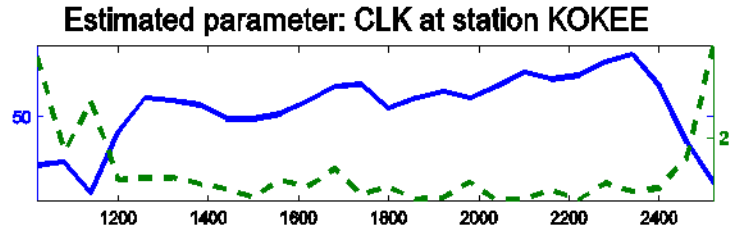


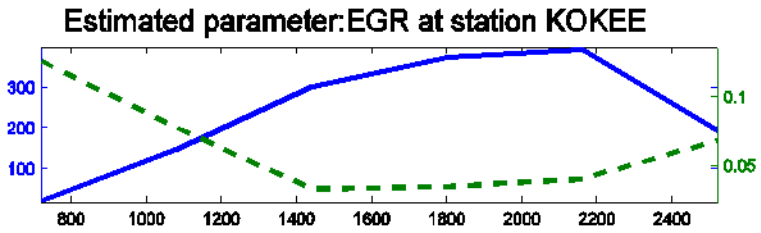


Number of observations used in estimation of gradients (360 min. intervals) at Session 02NOV05.

Results of Approach 3







there is a strong relationship between the formal error of an estimated parameter and the corresponding total number of observations supporting this parameter.

- The total number of observations supporting an auxiliary parameter will vary if the auxiliary parameter estimation intervals are defined as equally spaced by the standard parameterization.

Results of Approach3

Parameterization	Number of obs.at each interval	Chi-square of overall solution	Used relative constraints (cm)
par.1	10-20 for ZWD and clock 40-50 for gradients	2.0031	ZWD: 1.086 Clock: 0.942 Gradients: 0.030
par.2	5-10 for ZWD and clock 40-50 for gradients	0.5180	ZWD: 0.791 Clock: 0.686 Gradients: 0.030
par.3	5-10 for ZWD and clock 50-60 for gradients	0.5254	ZWD: 0.791 Clock: 0.686 Gradients: 0.033
par.4	10-20 for ZWD and clock 60-70 for gradients	2.1640	ZWD: 1.086 Clock: 0.942 Gradients: 0.037
par.5	5-10 for ZWD and clock 20-30 for gradients	0.5017	ZWD: 0.791 Clock: 0.686 Gradients: 0.021
current used option (default)	changes in each interval	4.0623	ZWD:1.5 Clock:1.3 Gradients: 0.05

The different parameterization options differ in the total number of supporting observations (column 2 of Table 1) at each parameter estimation interval.

Results of Approach3

- Using shorter time intervals for the ZWD/clk/NGR/EGR parameters results in a smaller chi-square calculated for the constraints and the observations.
- The corresponding loss of redundancy does not significantly control the quality of the solution.

One of the stations has a large diurnal clock variation, that not well modelled by a piece-wise linear function because the interval length is too large. The significant improvement of chi-square of the overall solution (a posteriori variance factor) is thus expected.

For other sessions, the improvement may not be as large as for this session.

Tanır Kayıkcı, et al 2015 shows that

- that *approach2* and *approach3* provide results better than the *standard approach* (currently used parameterization in VieVS software) for VLBI single session analysis with the least squares solution of VieVS.
- An automatic optimized parameterization for auxiliary parameters can be developed in VLBI single session least-squares analyses probably combining all three approaches.

THANKS FOR LISTENING