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Vie_LSM V2.2 (part 1: basics)

Kamil Teke and Johannes Böhm

VieVS User Workshop
September 23-24, 2015
Vienna, Austria

VieVS
Vienna VLBI Software

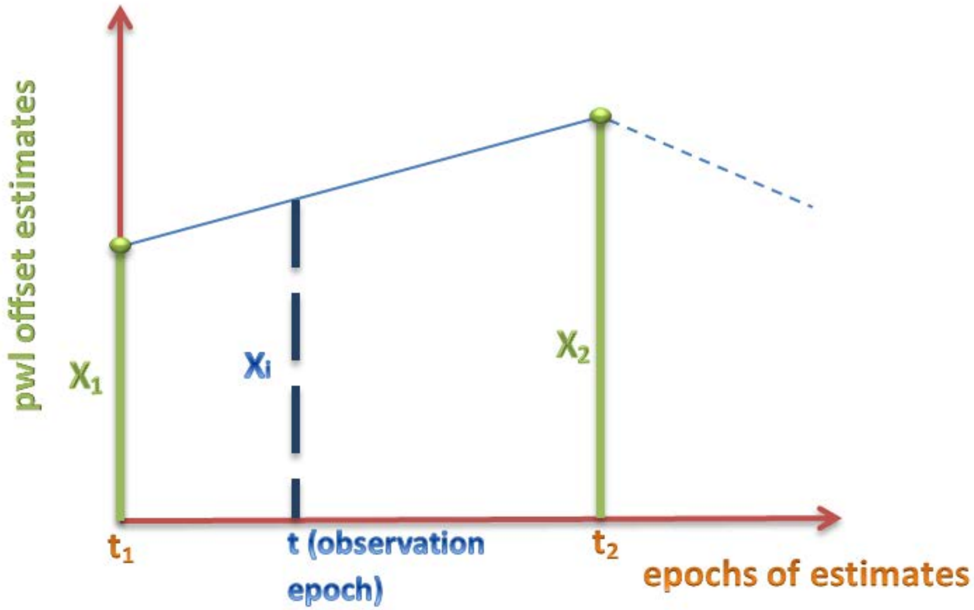
Introduction

- “vie_lsm” is a module of “VieVS”, which estimates geodetic parameters with least squares adjustment from VLBI observations.
- All the parameters can be estimated as piece-wise linear offsets (PWLO) in sub-daily and daily temporal resolution.

Estimated parameters per session are:

- Clocks (offset (cm), rate (cm/day), quadratic term (cm/day^2), PWLO (cm)),
- Zenith wet delays (cm) as PWLO,
- Troposphere gradients (cm) as PWLO,
- EOP (mas and ms) as PWLO,
- Antenna coordinates in TRF (cm) as one offset per session or as PWLO,
- Source coordinates in CRF (declinations in mas and right ascensions in ms) as one offset per session or as PWLO.

CPWLO function



$$x_i = x_1 + \frac{t - t_1}{t_2 - t_1}(x_2 - x_1)$$

Partial derivatives of the delay model w.r.t. a parameter's first and second offset

$$\frac{\partial\tau(t)}{\partial x_1} = \frac{\partial\tau(t)}{\partial x_i}\cdot\frac{\partial x_i}{\partial x_1} \rightarrow \frac{\partial x_i}{\partial x_1} = 1 - \frac{t - t_j}{t_{j+1} - t_j}$$

$$\frac{\partial\tau(t)}{\partial x_2} = \frac{\partial\tau(t)}{\partial x_i}\cdot\frac{\partial x_i}{\partial x_2} \rightarrow \frac{\partial x_i}{\partial x_2} = \frac{t - t_j}{t_{j+1} - t_j}$$

$$t_j < t < t_{j+1}$$

Least-Squares Adjustment in vie_lsm_v22

$$A = \begin{bmatrix} A(1).sm & \cdots & A(15).sm \end{bmatrix}$$

design matrix of real observation equations

$$H = \begin{bmatrix} H(1).sm & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & H(15).sm \end{bmatrix}$$

design matrix of pseudo-observation equations (constraints)

$$N = \begin{bmatrix} A^T PA + H^T P_H H & C^T \\ C & 0 \end{bmatrix} \qquad b = \begin{bmatrix} A^T Poc + H^T P_H och \\ b_c \end{bmatrix}$$

bc is a zero vector (due to NNT and NNR conditions)

parameter vector (estimates)

$$x = N^{-} b \qquad m_0 = (v^T P v + v_H^T P_H v_H) / (n_{obs} + n_{constr} - n_{unk})$$

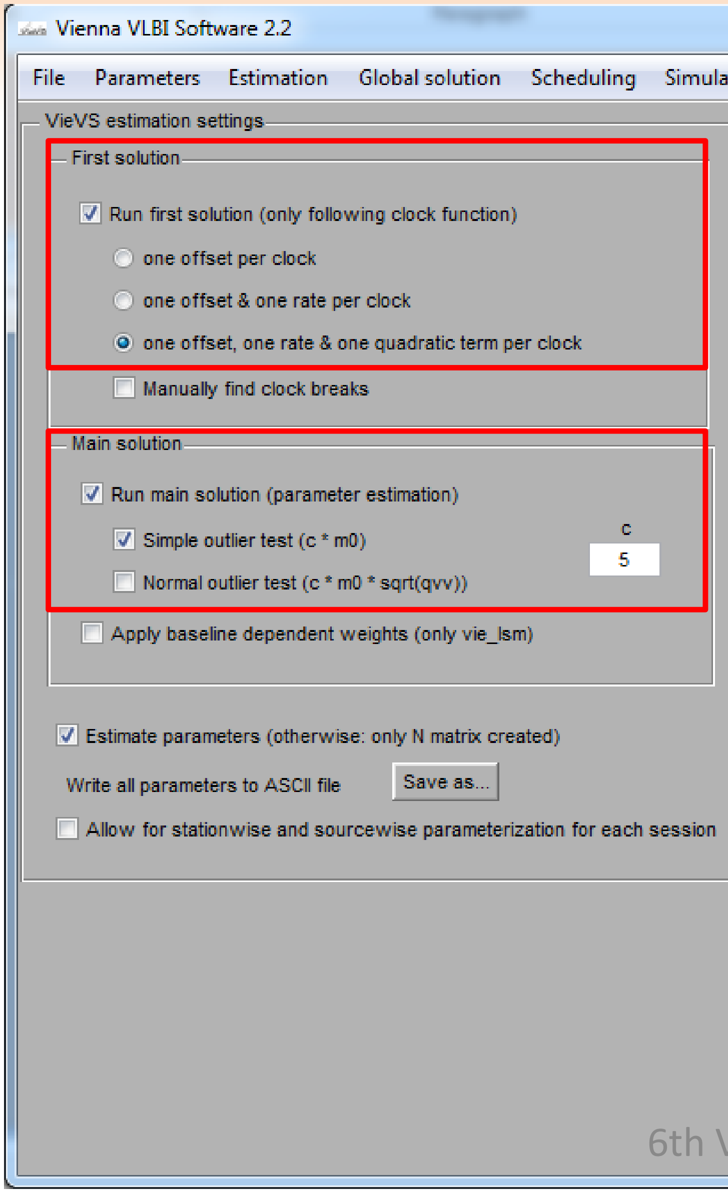
$$K_x = m_0 N^{-}$$

variance-covariance matrix of the estimates

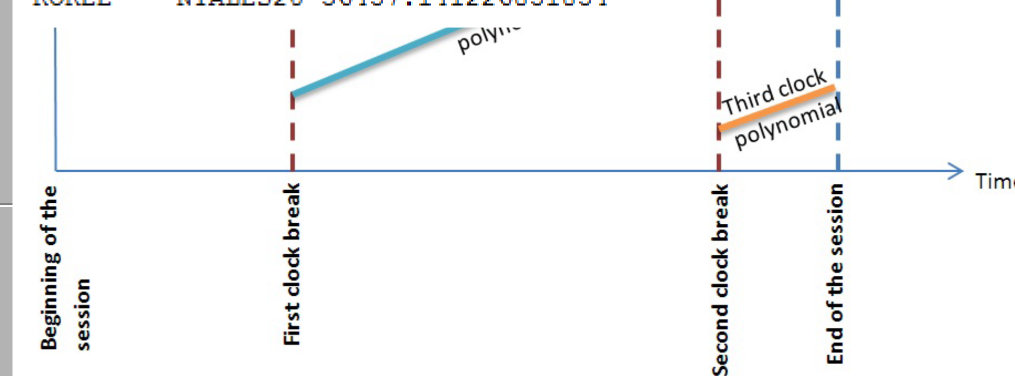
Reducing large clock errors and correcting clock breaks in a first least-sqaures solution

A first LS solution is done for reducing large clock errors from the observations and for fixing clock breaks

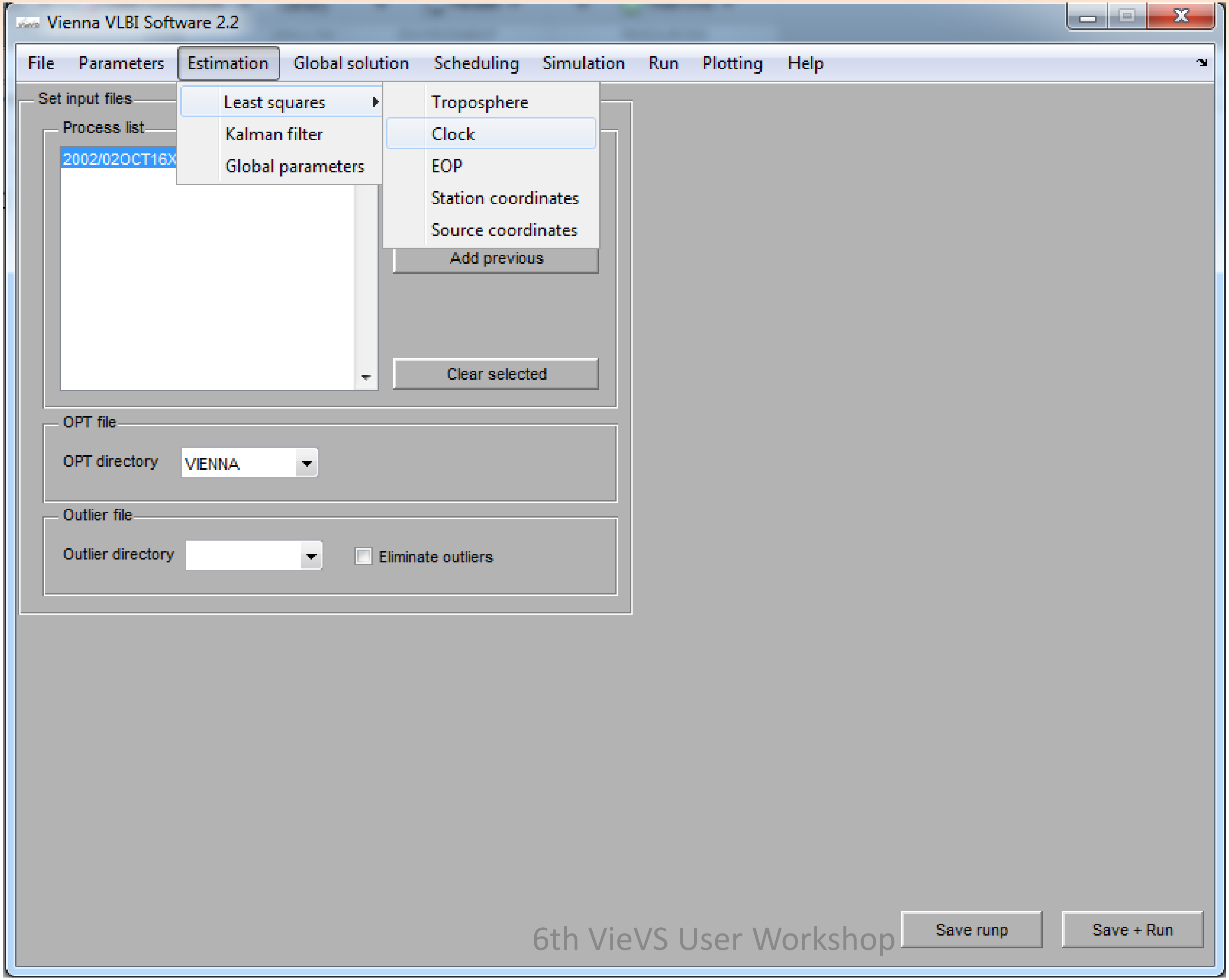
New outlier observations are detected and written to text files VieVS/DATA/OUTLIER/YOURDIR/YEAR/SESSNAME.OUT



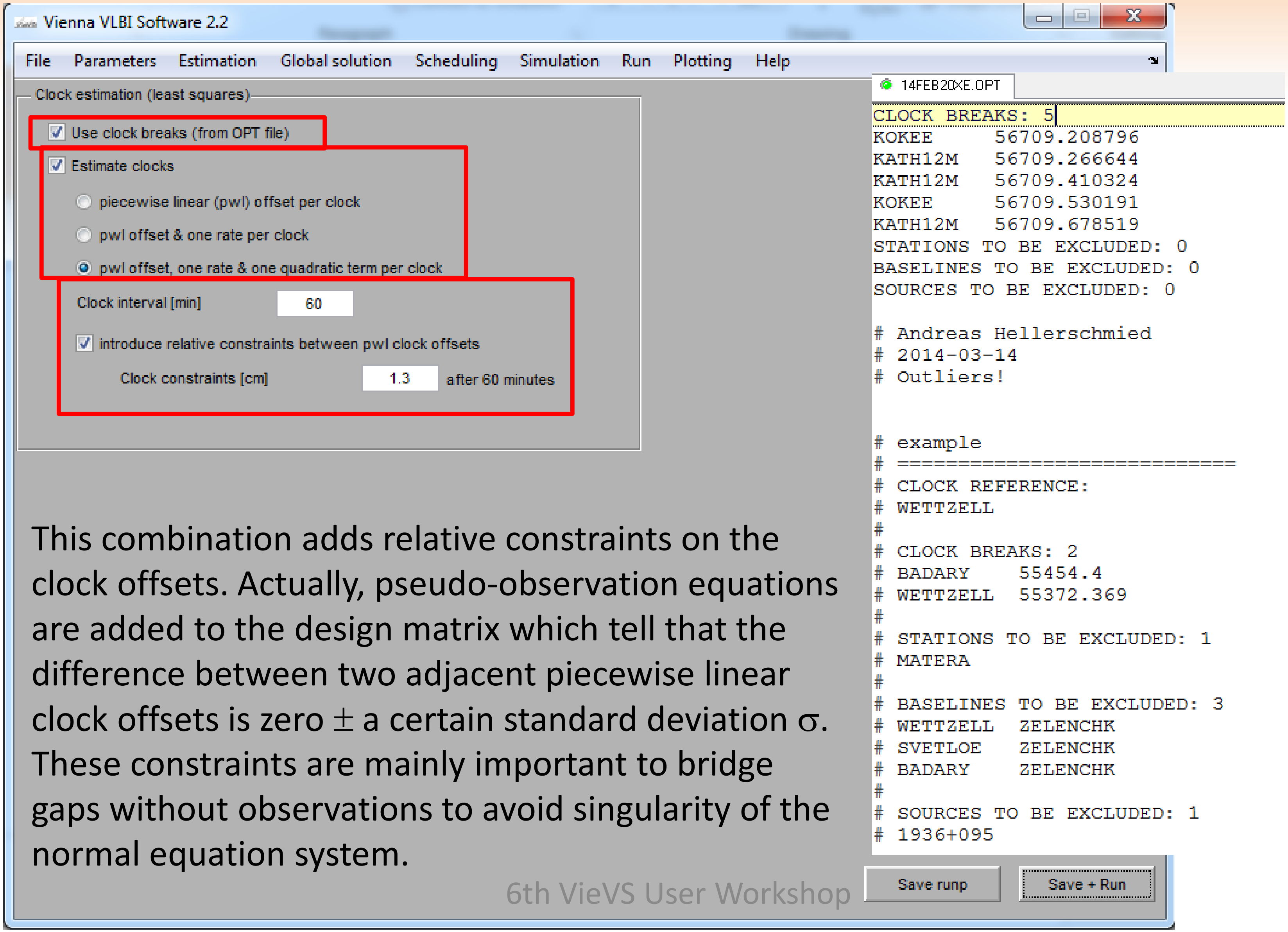
KOKEE	MATERA	56457.213020833333
KOKEE	WETTZELL	56457.141226851854
KOKEE	MATERA	56457.383483796293
FORTLEZA	MATERA	56457.416435185187
KOKEE	MATERA	56457.653912037036
HOBART12	TIGOCONC	56456.884803240740
KOKEE	NYALES20	56457.141226851854



Parameterisation of Least-Squares Adjustment in VieVS

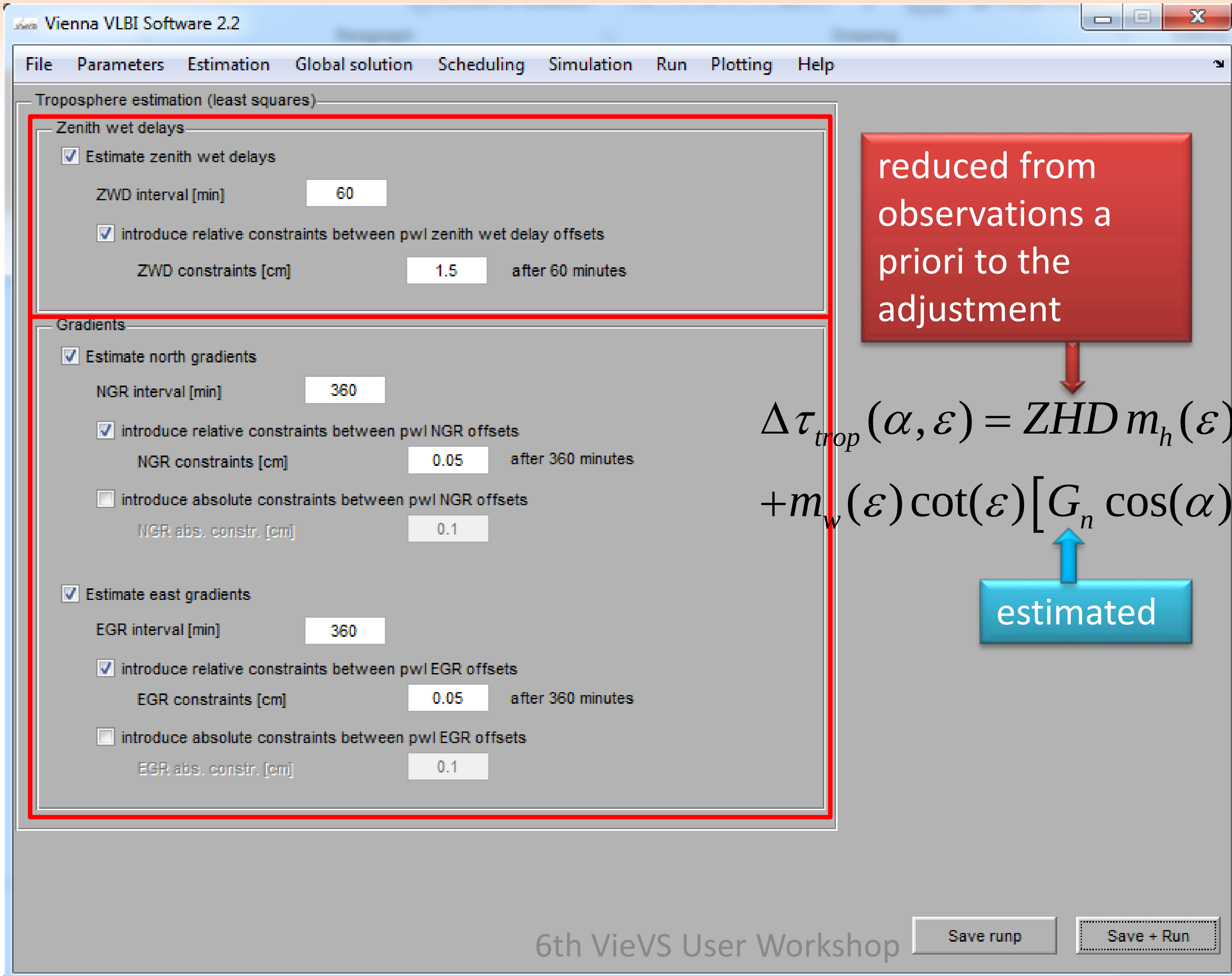


Clocks
(Coefficients of a quadratic function and PWLO)



This combination adds relative constraints on the clock offsets. Actually, pseudo-observation equations are added to the design matrix which tell that the difference between two adjacent piecewise linear clock offsets is zero ± a certain standard deviation σ. These constraints are mainly important to bridge gaps without observations to avoid singularity of the normal equation system.

Tropopshere delays
(Zenith wet delays, north and east gradients)



reduced from observations a priori to the adjustment

estimated

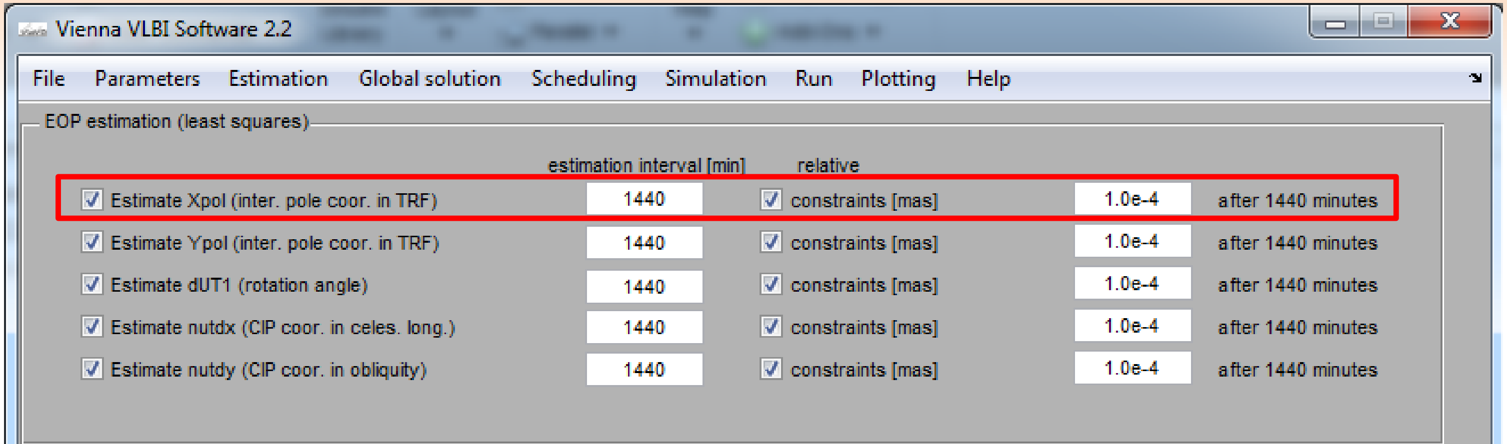
$$\Delta\tau_{trop}(\alpha,\varepsilon) = \underbrace{ZHD}_{\text{reduced from observations a priori to the adjustment}}\, m_h(\varepsilon) + \underbrace{ZWD}_{\text{estimated}}\, m_w(\varepsilon)$$

$$+ m_w(\varepsilon)\cot(\varepsilon)\left[\underbrace{G_n}_{\text{estimated}}\cos(\alpha) + \underbrace{G_e}_{\text{estimated}}\sin(\alpha)\right]$$

estimated

estimated

Earth Orientation Parameters

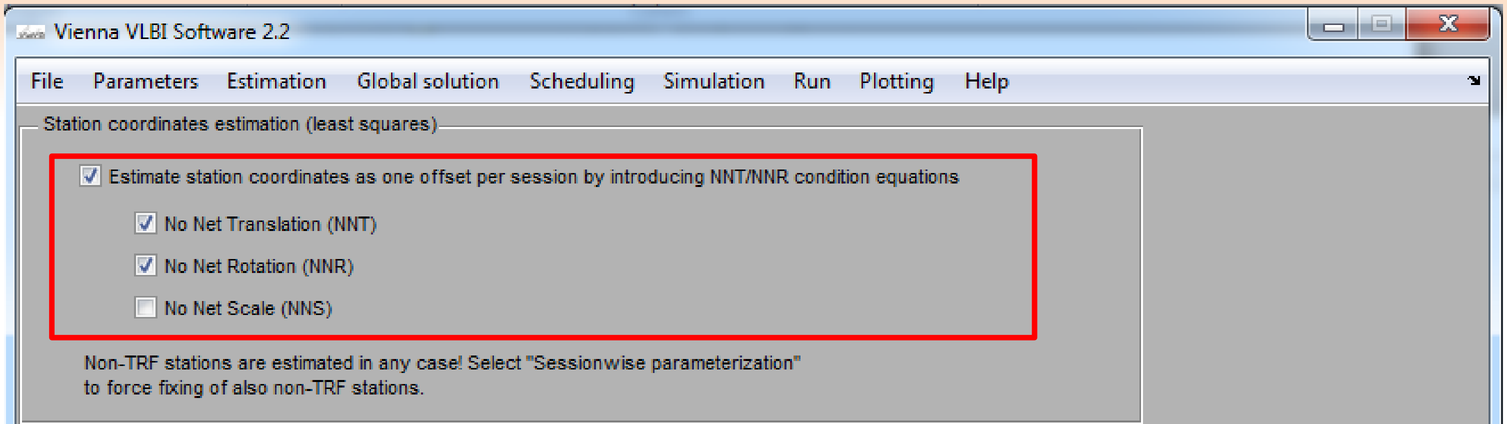


If you want to estimate one constant value per session, the recommendation is to set the parameterization as shown above. Very strong relative constraints of 1e-4 m(a)s/day take care that the estimates are the same over the session.

Example: The session is from 18 UT to 18 UT. Then, three piecewise linear offsets are set up for each EOP. (They are set up a midnight before the session, at midnight during the session, and at midnight after the session.) The strong constraints take care that all three estimates per session are the same.

Save runp Save + Run

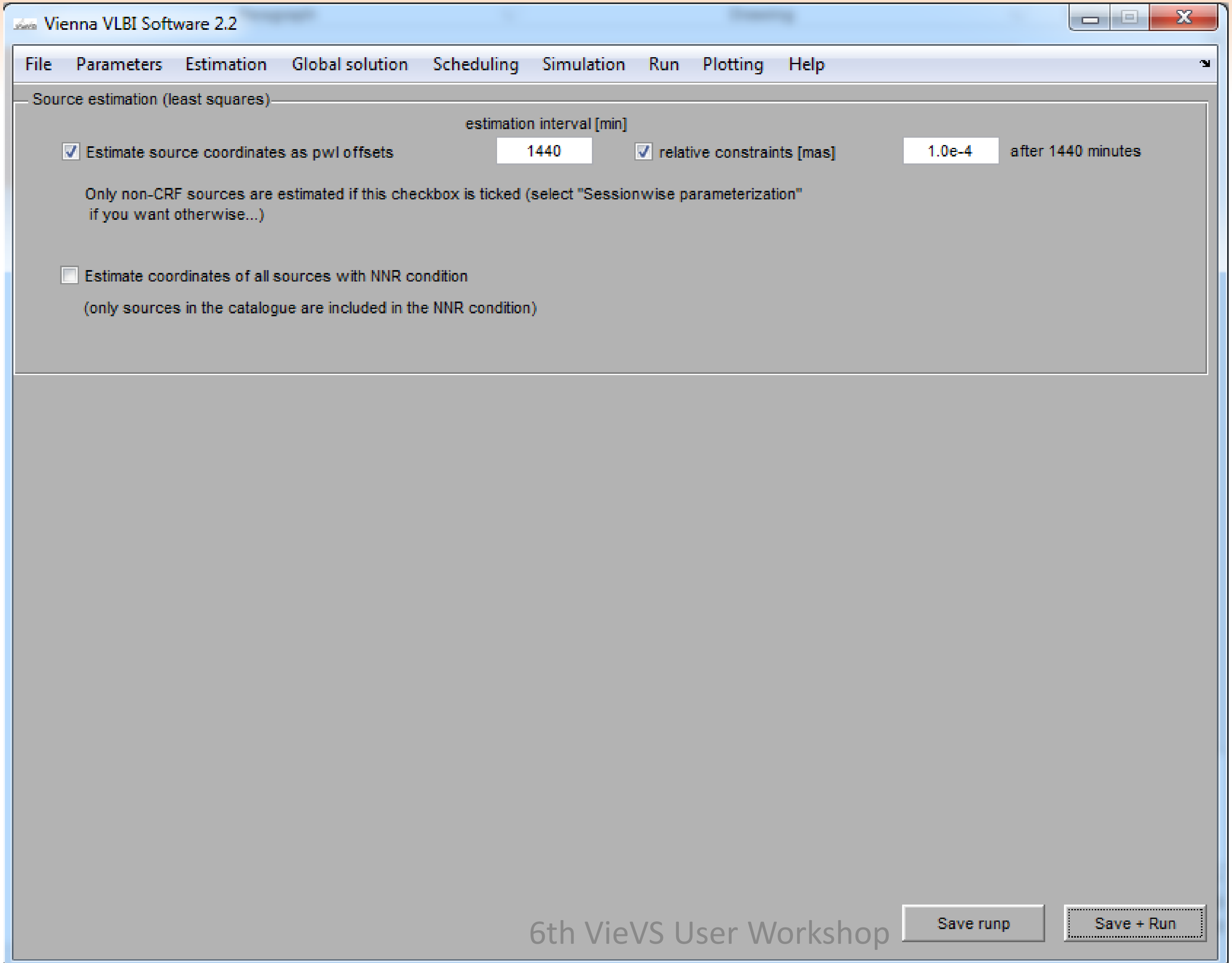
Antenna TRF coordinates



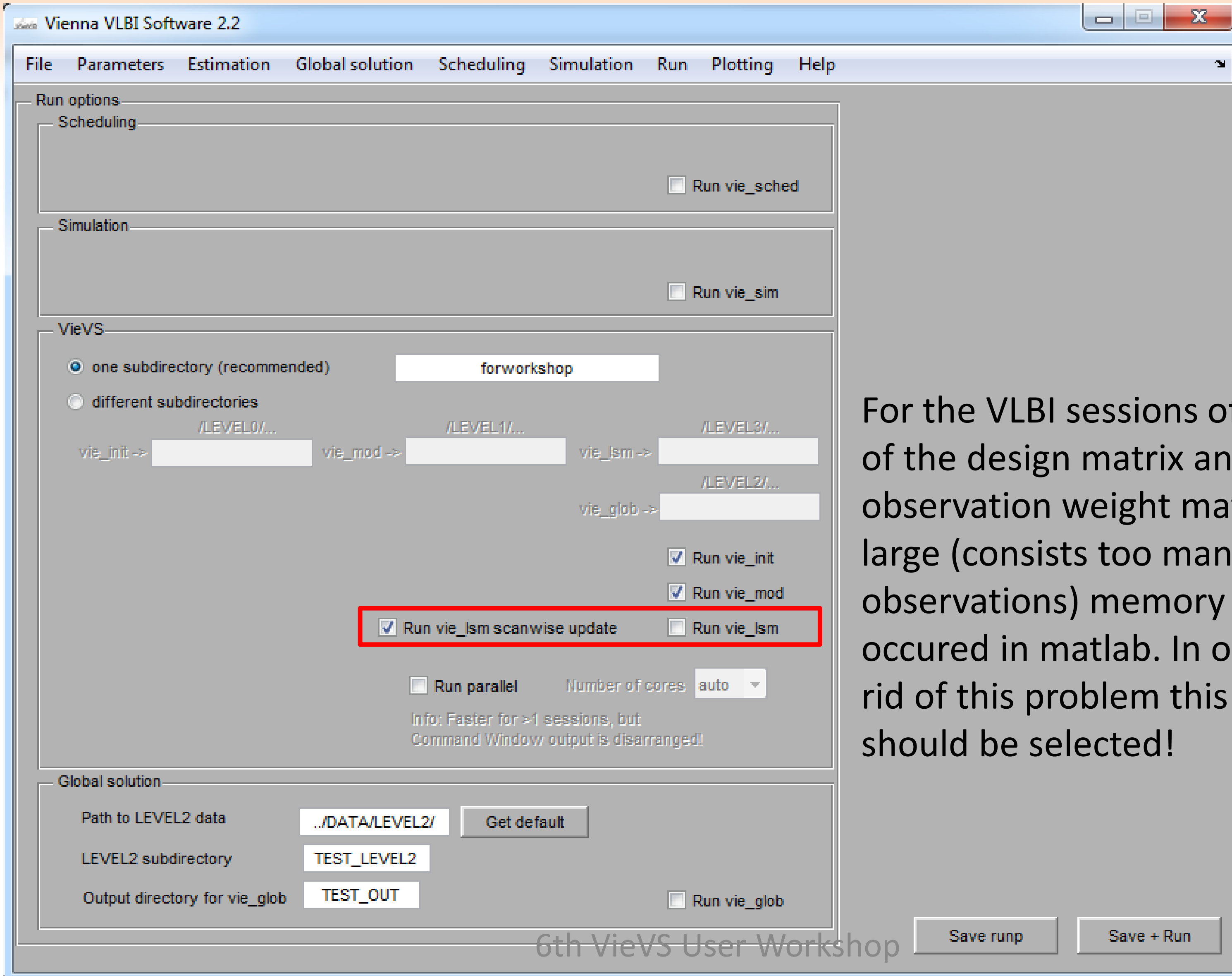
- NNT and NNR conditions are imposed to provide the estimated TRF would neither translate nor rotate w.r.t. the a priori TRF. Thus, 3 translations and 3 rotations between the estimated and a priori TRF will be zero.
- Non-TRF stations will not be a part of the datum when NNT and NNR are introduced!
- Non-TRF station coordinates will be estimated even station coordinates are not estimated!
- The scale of the estimated TRF for each session will be defined free from the scale of the a priori TRF.

Save runp Save + Run

Source CRF coordinates



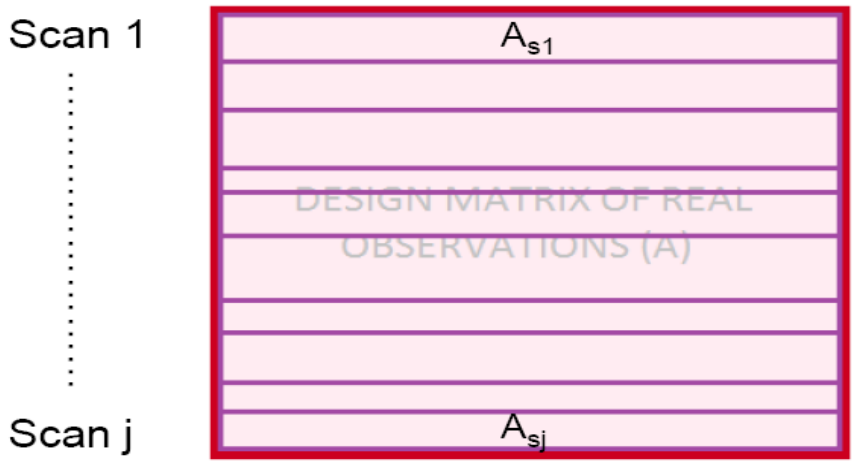
vie_lsm scan-wise update



For the VLBI sessions of which size of the design matrix and observation weight matrix is too large (consists too many observations) memory error occured in matlab. In order to get rid of this problem this option should be selected!

Scan-wise update of normal equation system

1 A-matrix per scan



$$N_{s1} = A_{s1}^{T} \cdot P_{s1} \cdot A_{s1}$$

$$N_A = N_{s1} + N_{s2} + \ldots + N_{sj}$$

$$b_{s1} = A_{s1}^{T} \cdot P_{s1} \cdot oc_{s1}$$

$$b_A = b_{s1} + b_{s2} + \ldots + b_{sj}$$

j : number of scans in the session

Claudia Tierno Ros, Third VieVS user workshop, 11-13 September, 2012

Conclusions

- vie_lsm corrects clock breaks and detects outlier observations.
- vie_lsm provides SINEX input and datum free normal equations for global solutions.
- PWLO estimates of VieVS are in a good agreement with those derived from other space geodetic techniques.
- Scan-wise update of normal equation system ensures a successful process of the future sessions with lots of observations.

Thanks for your attention!