VIE_LSM_V20

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VieVS User Workshop

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Vienna

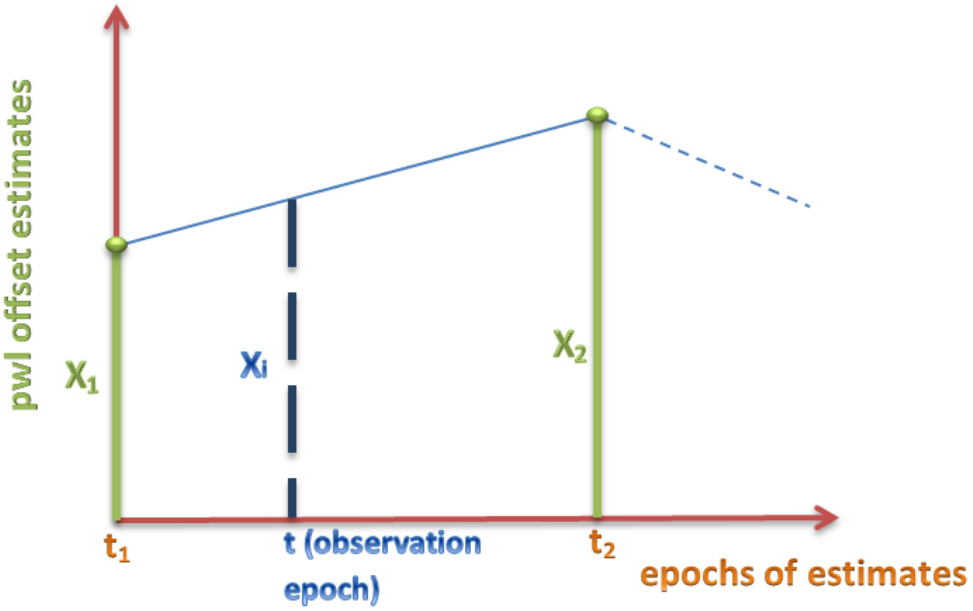
Introduction

- "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 continuous piece-wise linear offsets (CPWLO) in sub-daily and daily temporal resolution.

Estimated parameters are:

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

continuous piece-wise linear offsets (CPWLO)



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

Partial derivatives of the delay model w.r.t. a sub-daily parameter

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

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

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

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

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

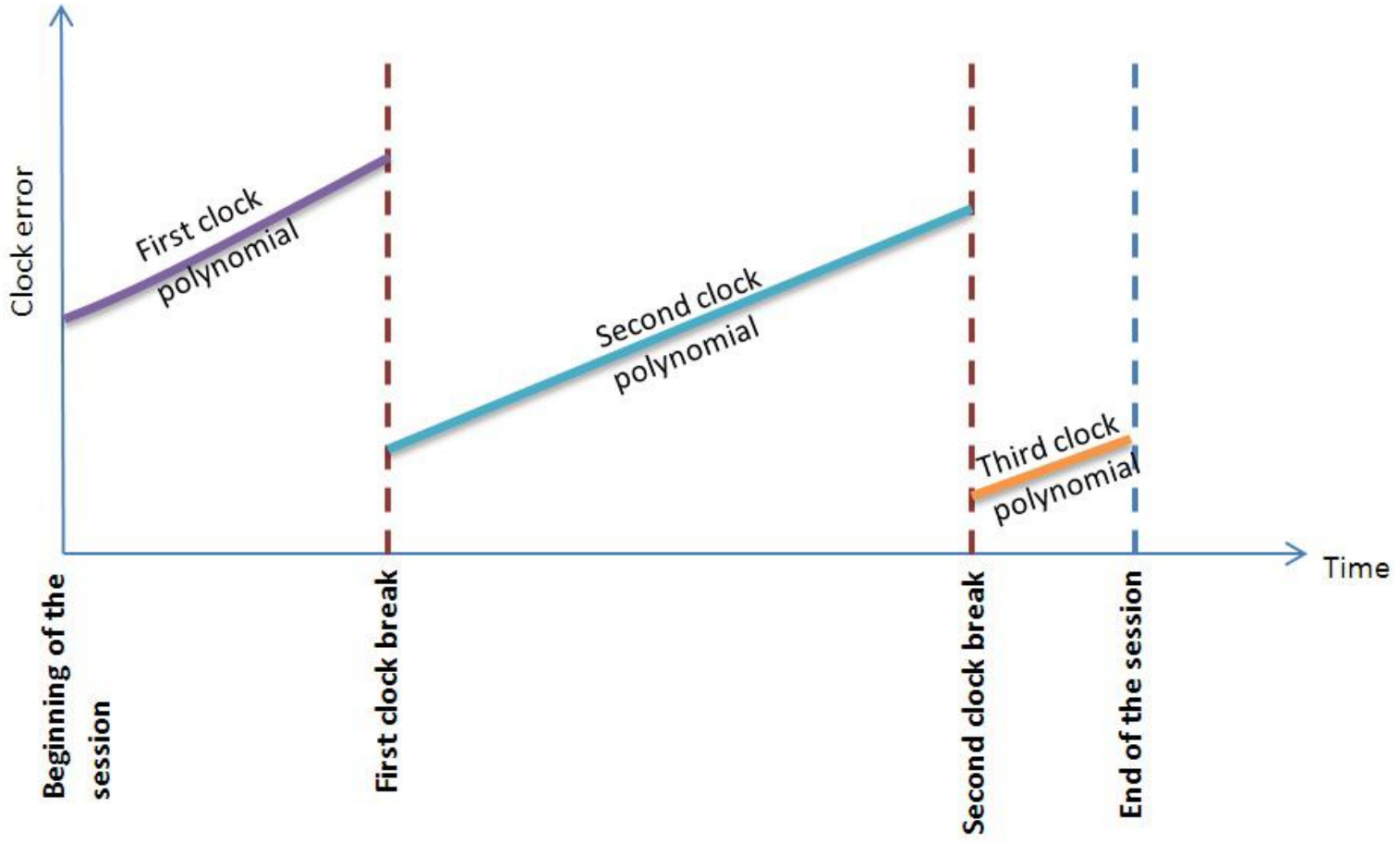
parameter vector (estimates)

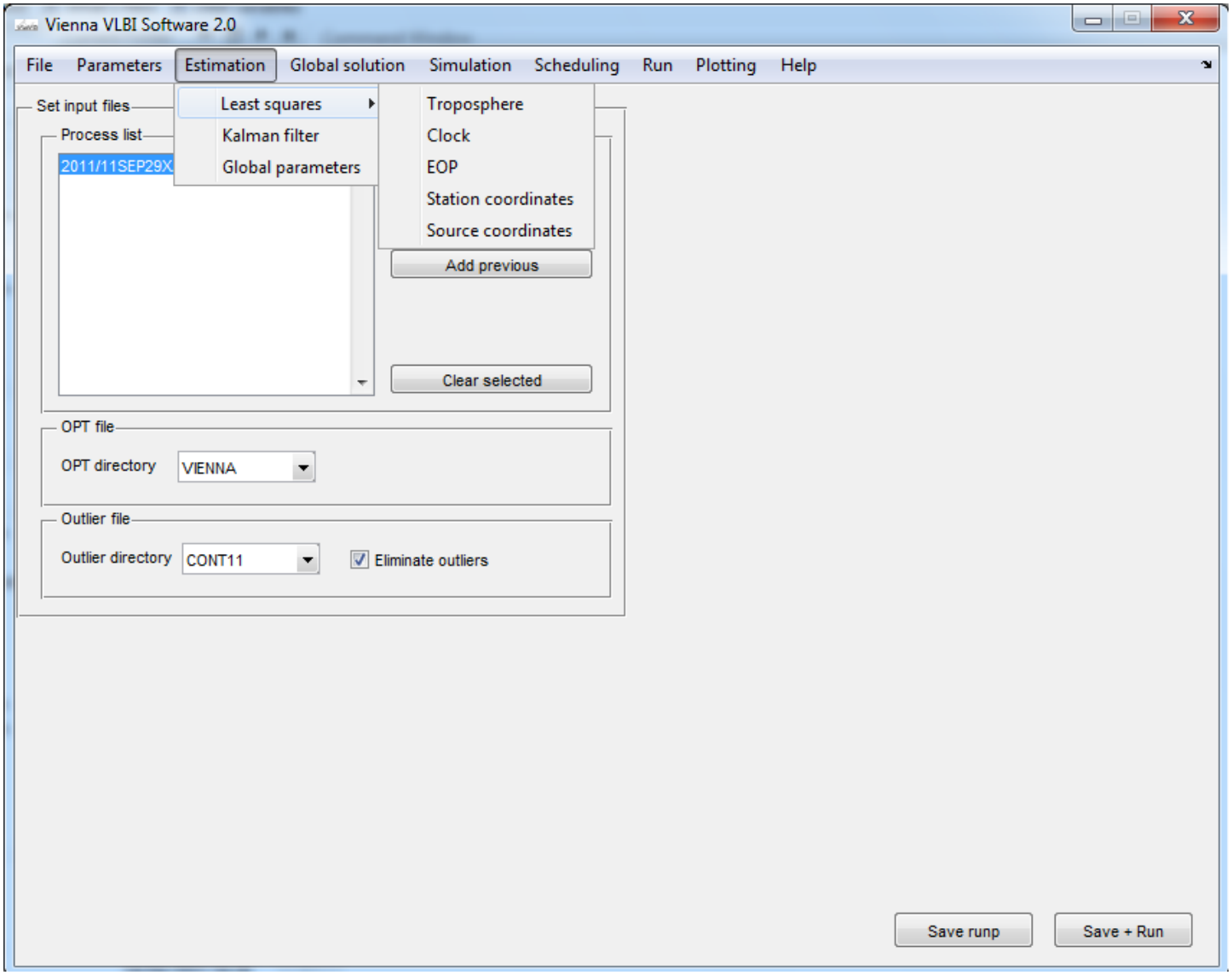
$$x = N^{-} b \qquad m_0 = (v^T Pv + v_H^T P_H v_H) / (n_{obs} + n_{constr} - n_{unk})$$

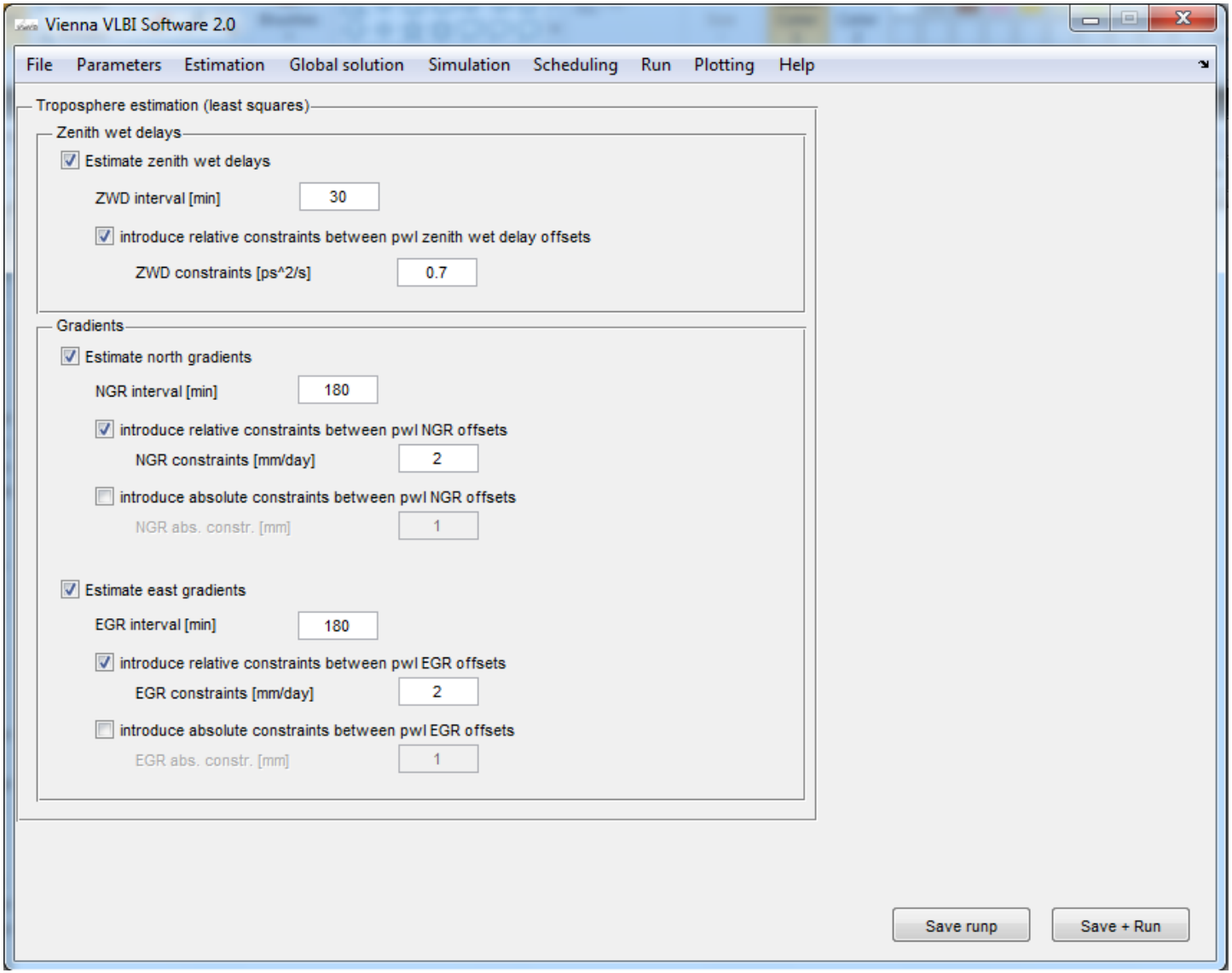
$$K_x = m_0 N^{-}$$

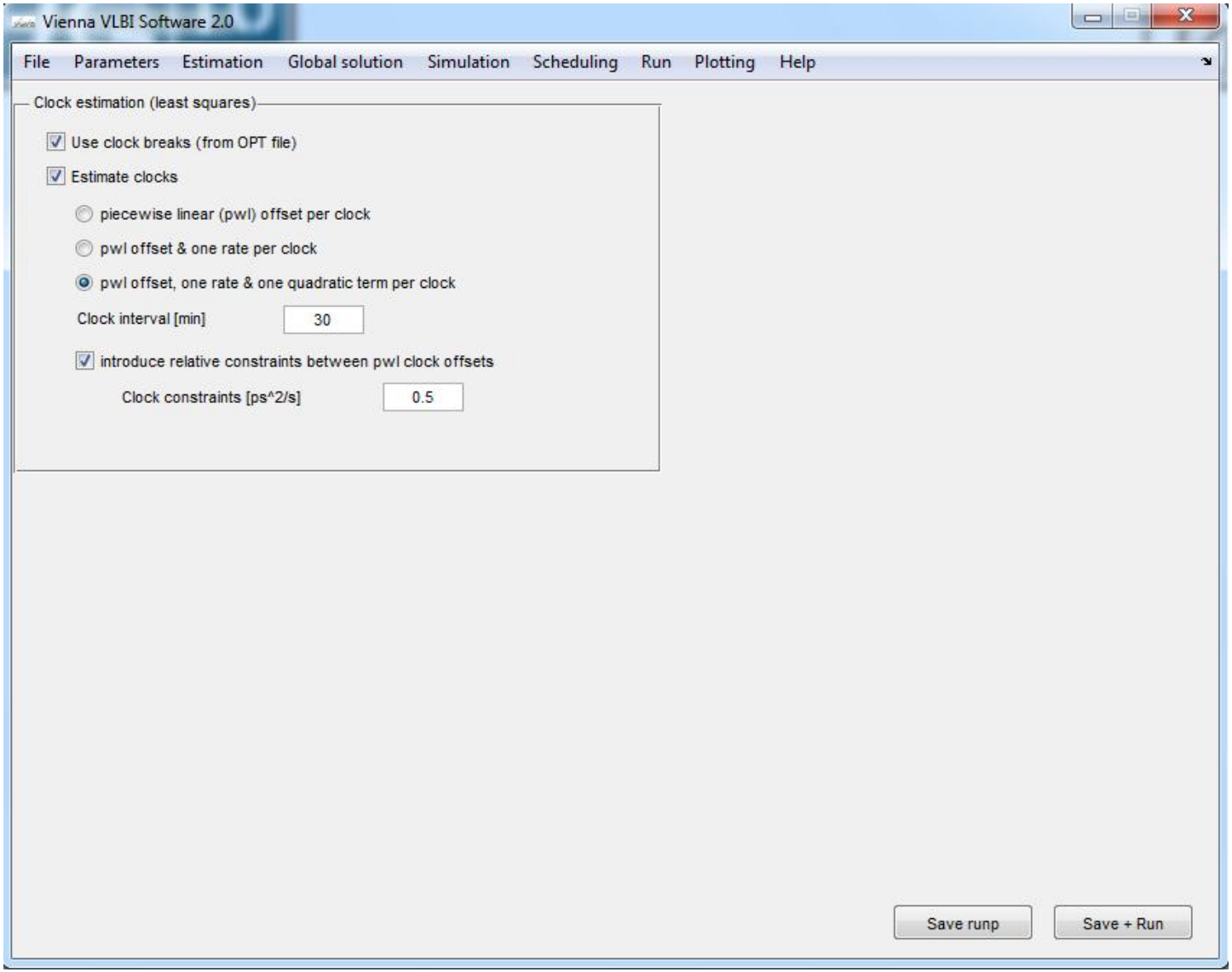
variance-covariance matrix of the estimates

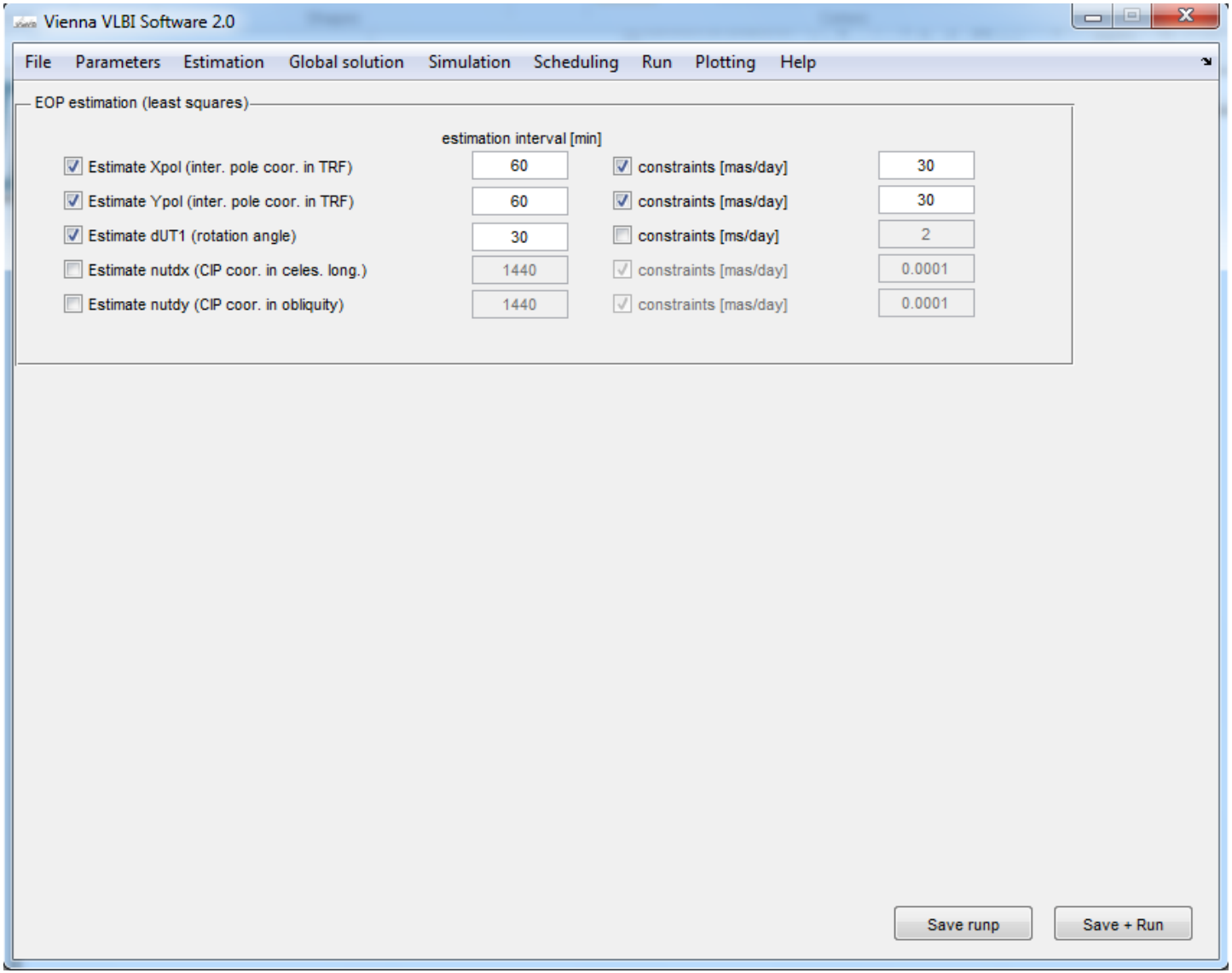
Modeling clock breaks

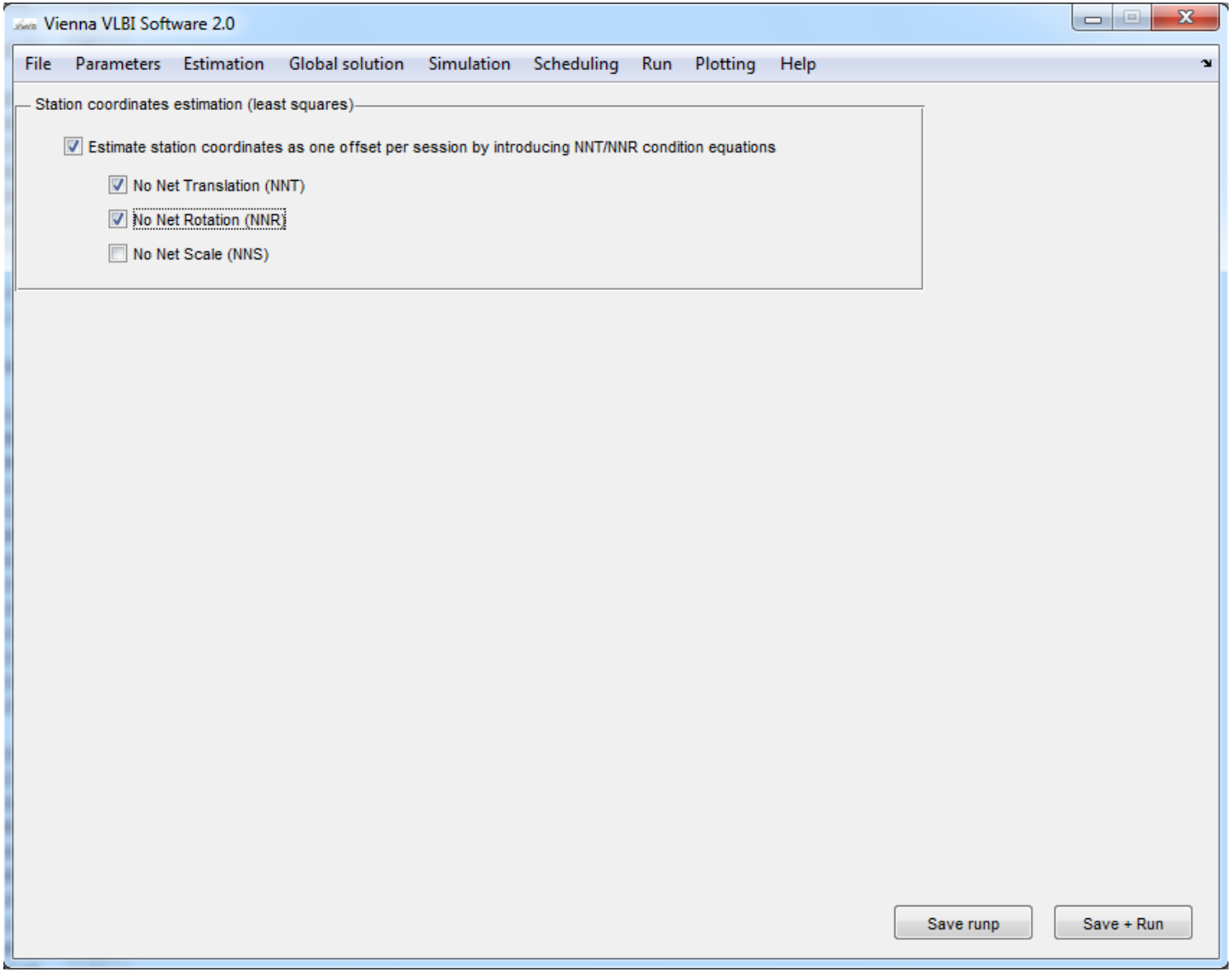


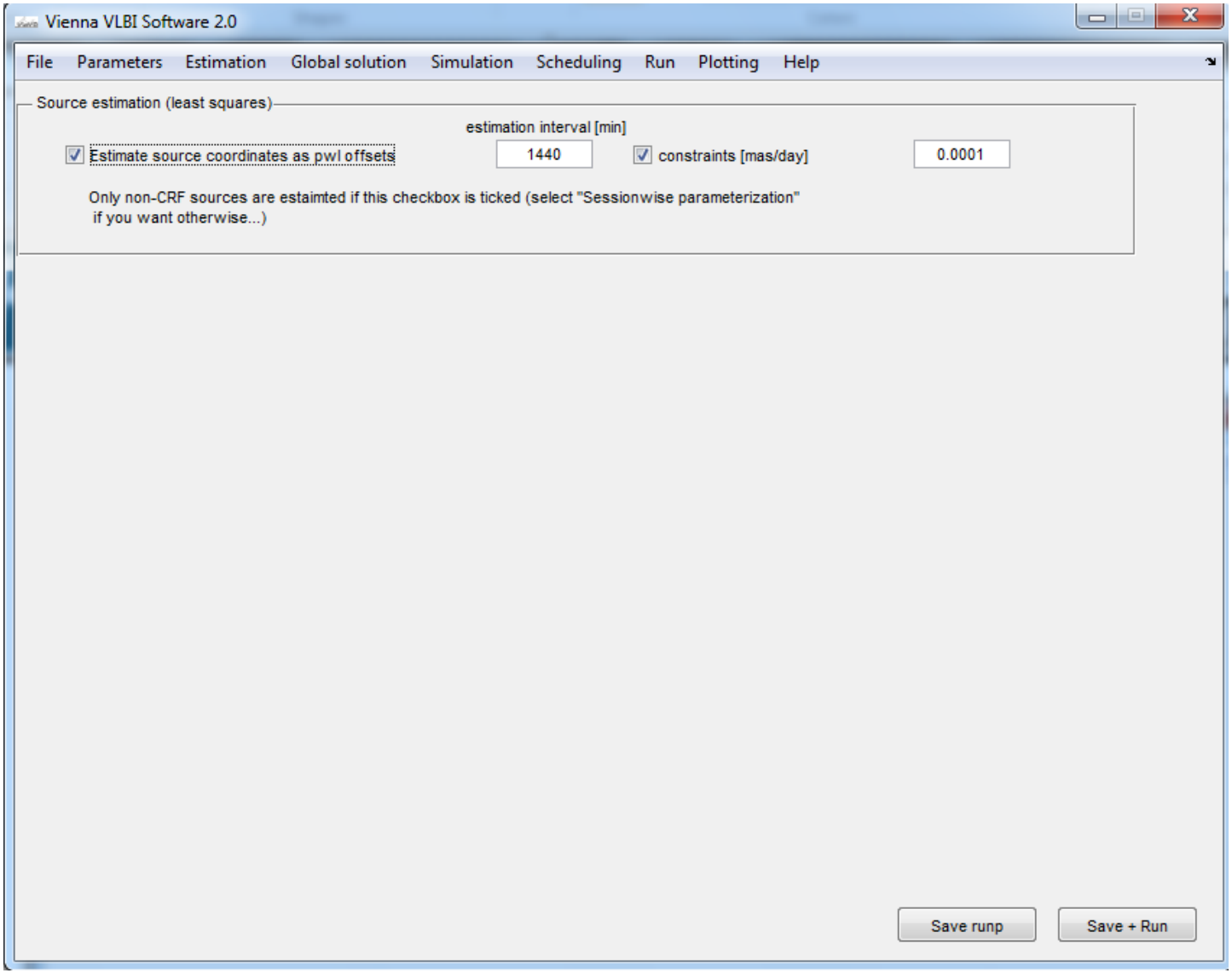

Vienna VLBI Software 2.0
File
Parameters
Estimation
Global solution
Simulation
Scheduling
Run
Plotting
Help
Least squares
Kalman filter
Global parameters
Troposphere
Clock
EOP
Station coordinates
Source coordinates
Set input files
Process list
2011/11SEP29X
Add previous
Clear selected
OPT file
OPT directory
VIENNA
Outlier file
Outlier directory
CONT11
Eliminate outliers
Save runp
Save + Run

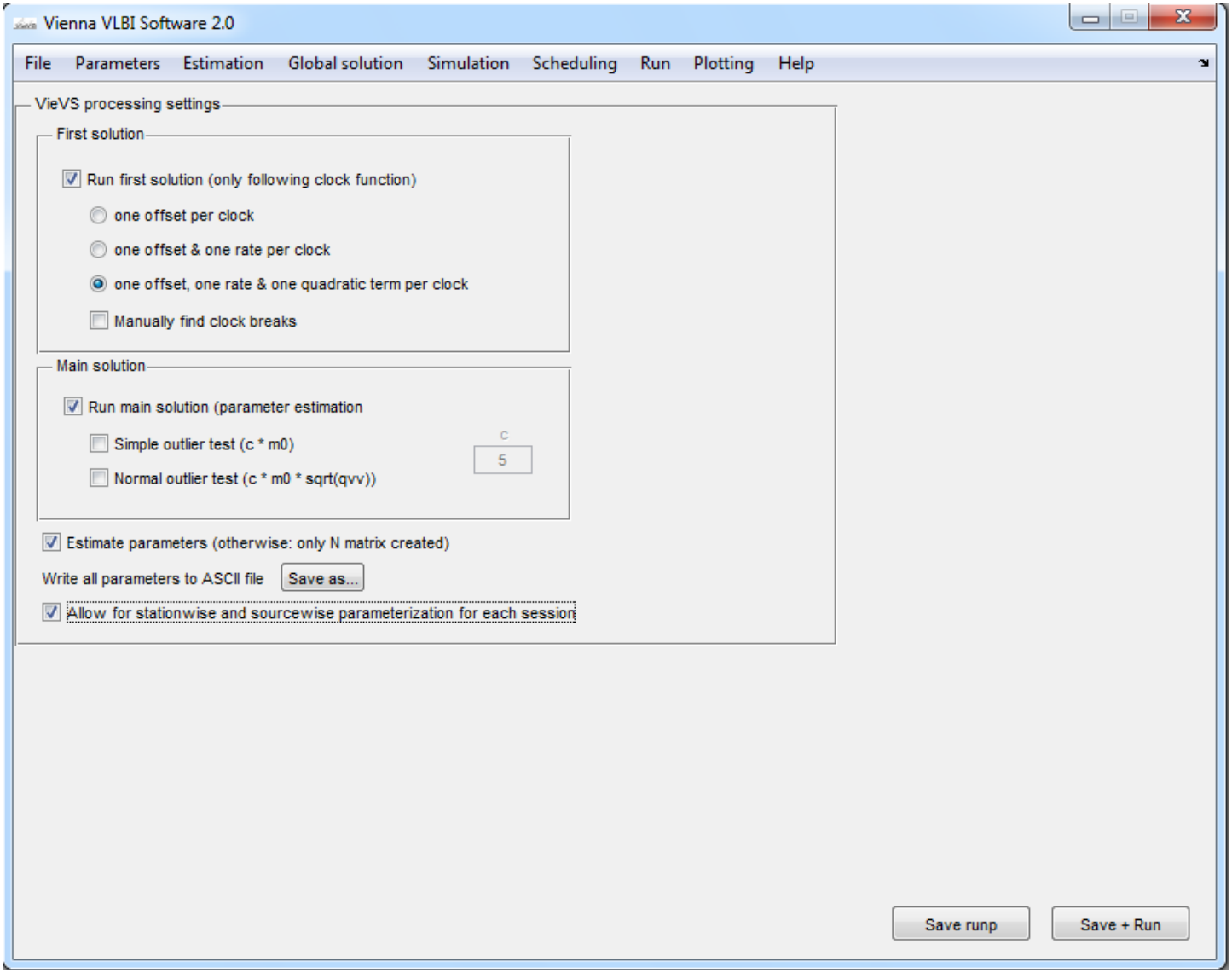

Vienna VLBI Software 2.0
File
Parameters
Estimation
Global solution
Simulation
Scheduling
Run
Plotting
Help
Troposphere estimation (least squares)
Zenith wet delays
Estimate zenith wet delays
ZWD interval [min]
30
introduce relative constraints between pwl zenith wet delay offsets
ZWD constraints [ps^2/s]
0.7
Gradients
Estimate north gradients
NGR interval [min]
180
introduce relative constraints between pwl NGR offsets
NGR constraints [mm/day]
2
introduce absolute constraints between pwl NGR offsets
NGR abs. constr. [mm]
1
Estimate east gradients
EGR interval [min]
180
introduce relative constraints between pwl EGR offsets
EGR constraints [mm/day]
2
introduce absolute constraints between pwl EGR offsets
EGR abs. constr. [mm]
1
Save runp
Save + Run


Vienna VLBI Software 2.0
File
Parameters
Estimation
Global solution
Simulation
Scheduling
Run
Plotting
Help
Clock estimation (least squares)
Use clock breaks (from OPT file)
Estimate clocks
piecewise linear (pwl) offset per clock
pwl offset & one rate per clock
pwl offset, one rate & one quadratic term per clock
Clock interval [min]
30
introduce relative constraints between pwl clock offsets
Clock constraints [ps^2/s]
0.5
Save runp
Save + Run

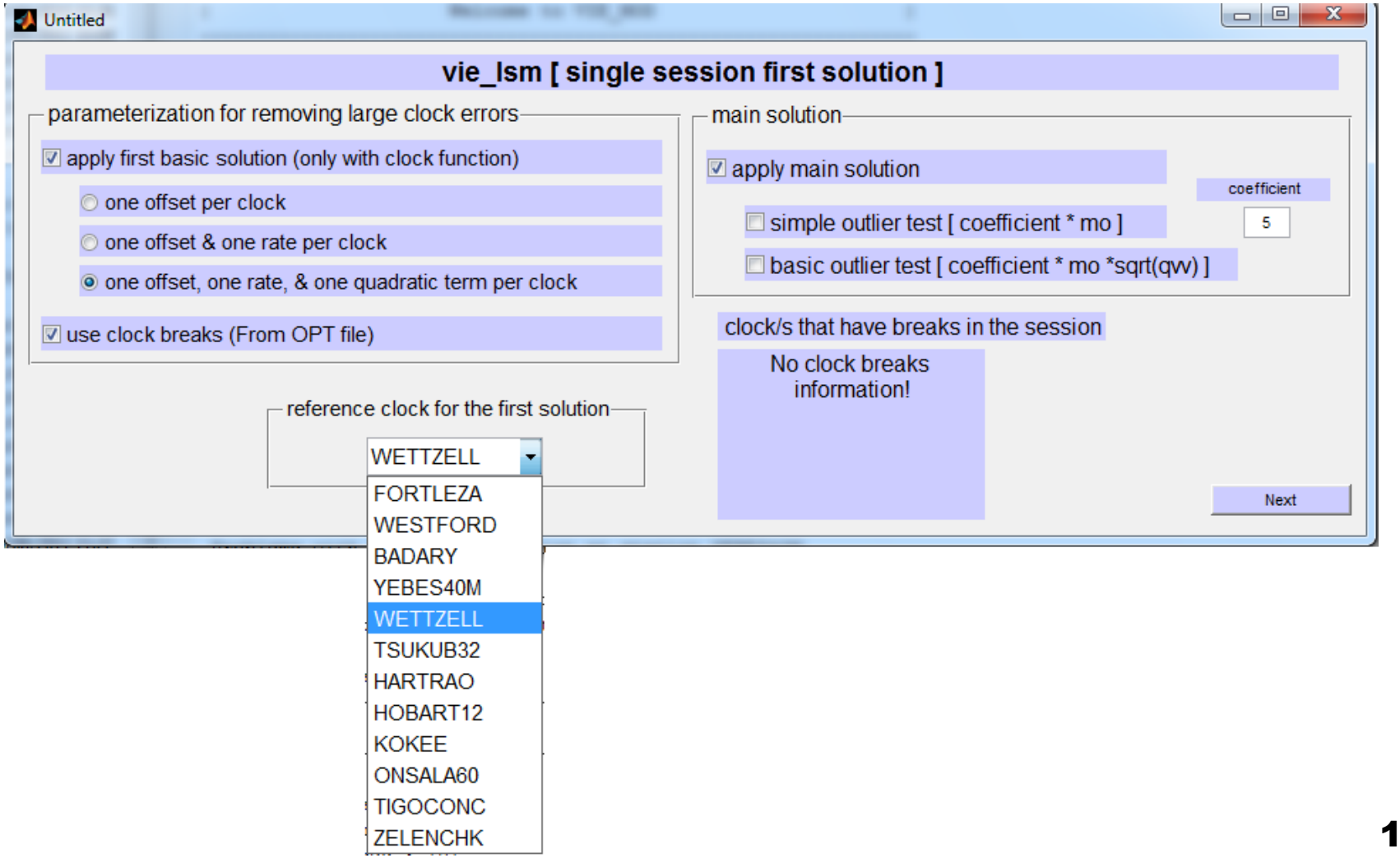

Vienna VLBI Software 2.0
File
Parameters
Estimation
Global solution
Simulation
Scheduling
Run
Plotting
Help
EOP estimation (least squares)
estimation interval [min]
Estimate Xpol (inter. pole coor. in TRF)
60
constraints [mas/day]
30
Estimate Ypol (inter. pole coor. in TRF)
60
constraints [mas/day]
30
Estimate dUT1 (rotation angle)
30
constraints [ms/day]
2
Estimate nutdx (CIP coor. in celes. long.)
1440
constraints [mas/day]
0.0001
Estimate nutdy (CIP coor. in obliquity)
1440
constraints [mas/day]
0.0001
Save runp
Save + Run


Vienna VLBI Software 2.0
File
Parameters
Estimation
Global solution
Simulation
Scheduling
Run
Plotting
Help
Station coordinates estimation (least squares)
Estimate station coordinates as one offset per session by introducing NNT/NNR condition equations
No Net Translation (NNT)
No Net Rotation (NNR)
No Net Scale (NNS)
Save runp
Save + Run

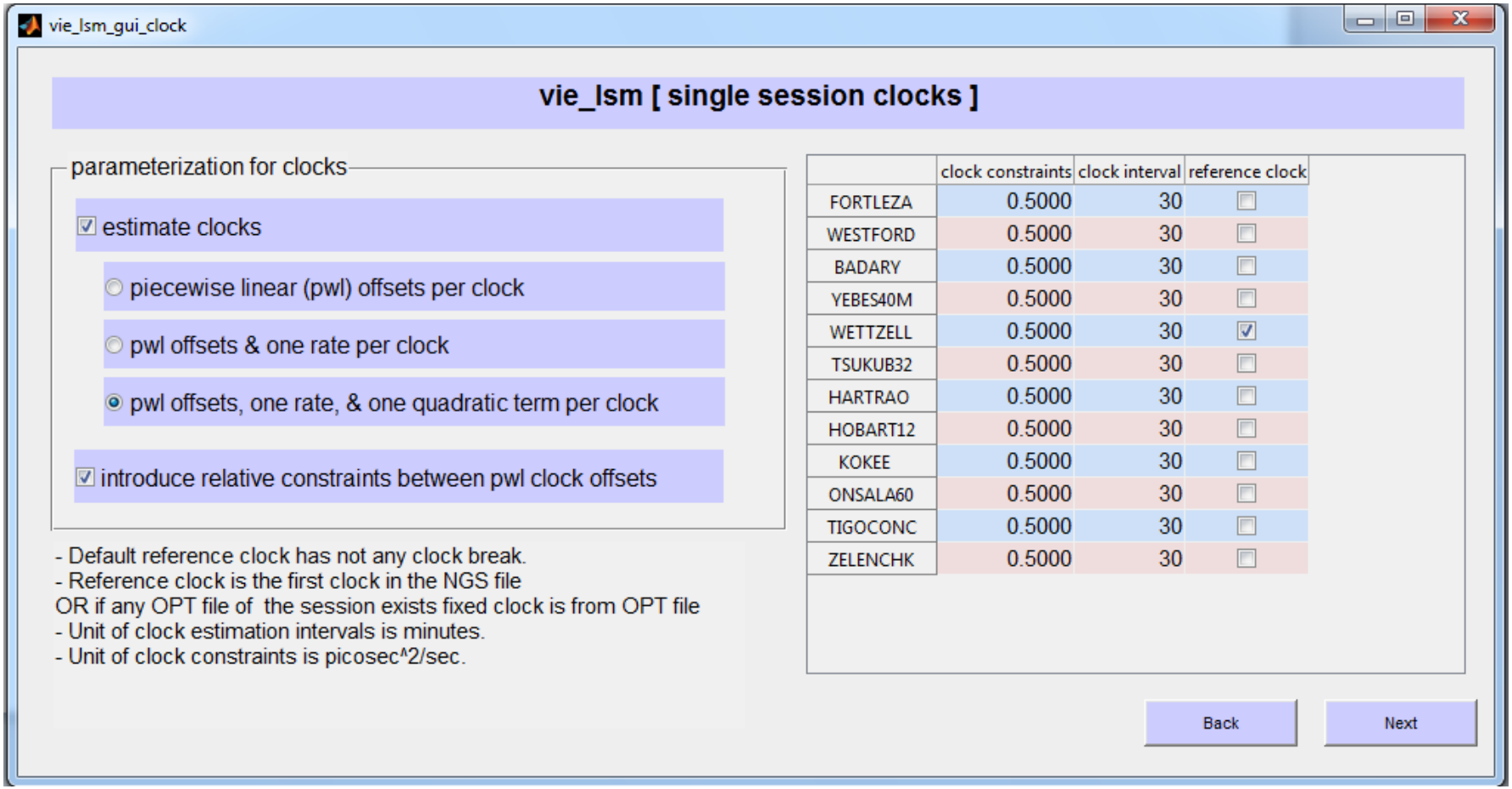

Vienna VLBI Software 2.0
File
Parameters
Estimation
Global solution
Simulation
Scheduling
Run
Plotting
Help
Source estimation (least squares)
estimation interval [min]
Estimate source coordinates as pwl offsets
1440
constraints [mas/day]
0.0001
Only non-CRF sources are estaimted if this checkbox is ticked (select "Sessionwise parameterization"
if you want otherwise...)
Save runp
Save + Run


Vienna VLBI Software 2.0
File
Parameters
Estimation
Global solution
Simulation
Scheduling
Run
Plotting
Help
VieVS processing settings
First solution
Run first solution (only following clock function)
one offset per clock
one offset & one rate per clock
one offset, one rate & one quadratic term per clock
Manually find clock breaks
Main solution
Run main solution (parameter estimation
Simple outlier test (c * m0)
Normal outlier test (c * m0 * sqrt(qvv))
c
5
Estimate parameters (otherwise: only N matrix created)
Write all parameters to ASCII file
Save as...
Allow for stationwise and sourcewise parameterization for each session
Save runp
Save + Run

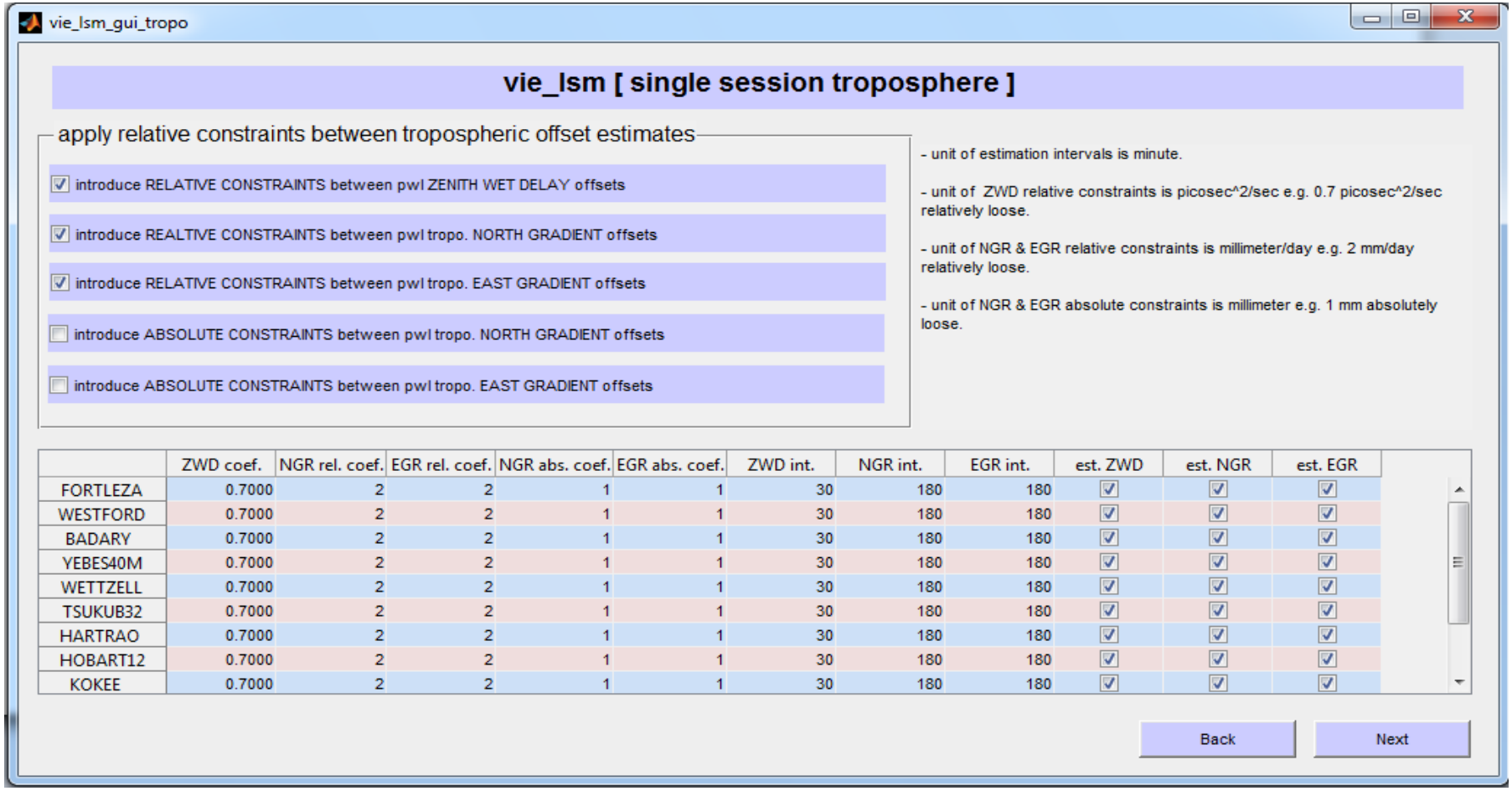
Clocks for first solution



Clocks

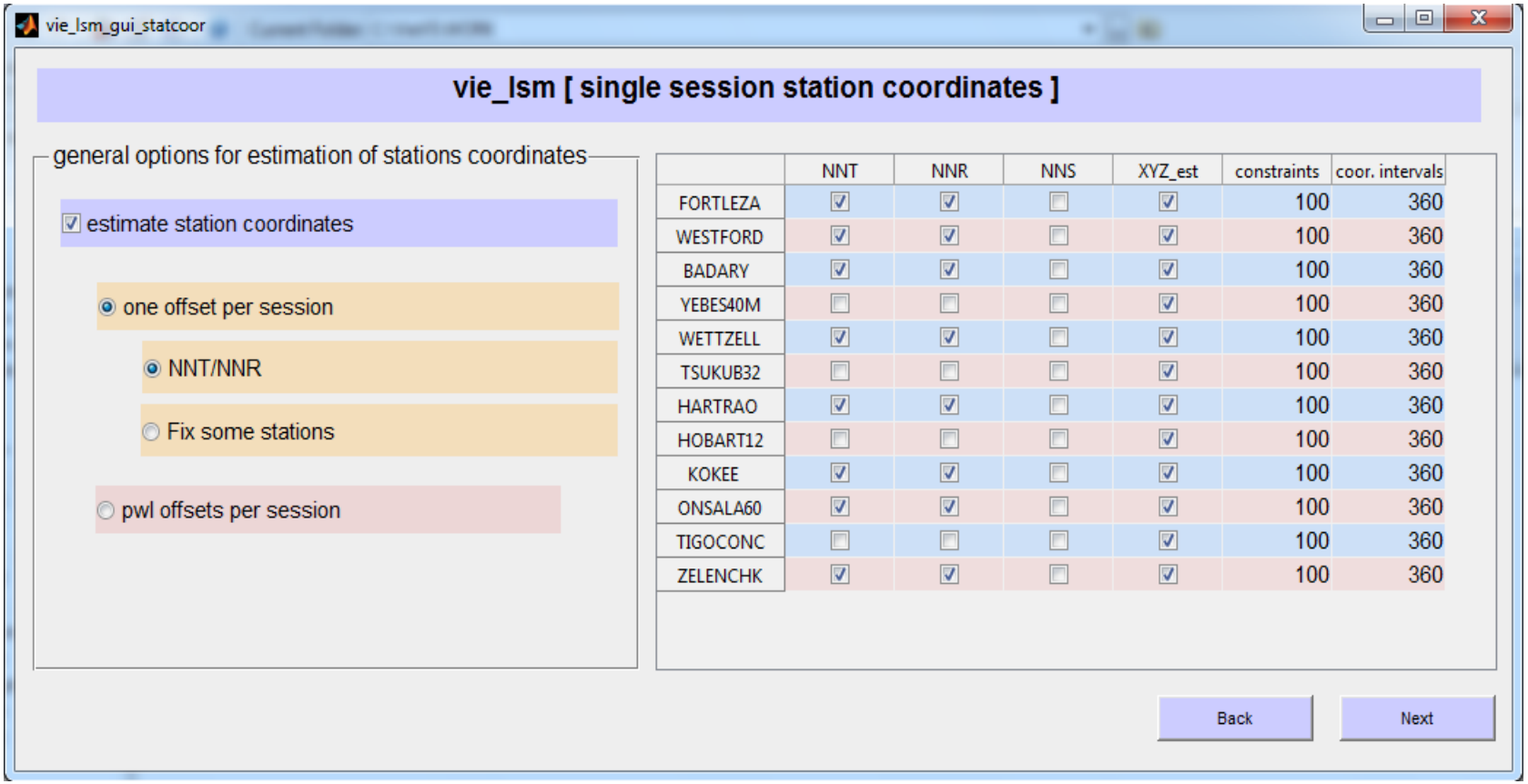

vie_lsm_gui_clock
vie_lsm [single session clocks]
parameterization for clocks
estimate clocks
piecewise linear (pwl) offsets per clock
pwl offsets & one rate per clock
pwl offsets, one rate, & one quadratic term per clock
introduce relative constraints between pwl clock offsets
- Default reference clock has not any clock break.
- Reference clock is the first clock in the NGS file
OR if any OPT file of the session exists fixed clock is from OPT file
- Unit of clock estimation intervals is minutes.
- Unit of clock constraints is picosec^2/sec.
clock constraints
clock interval
reference clock
FORTLEZA 0.5000 30
WESTFORD 0.5000 30
BADARY 0.5000 30
YEBES40M 0.5000 30
WETTZELL 0.5000 30
TSUKUB32 0.5000 30
HARTRAO 0.5000 30
HOBART12 0.5000 30
KOKEE 0.5000 30
ONSALA60 0.5000 30
TIGOCONC 0.5000 30
ZELENCHK 0.5000 30
Back
Next

Troposphere delay



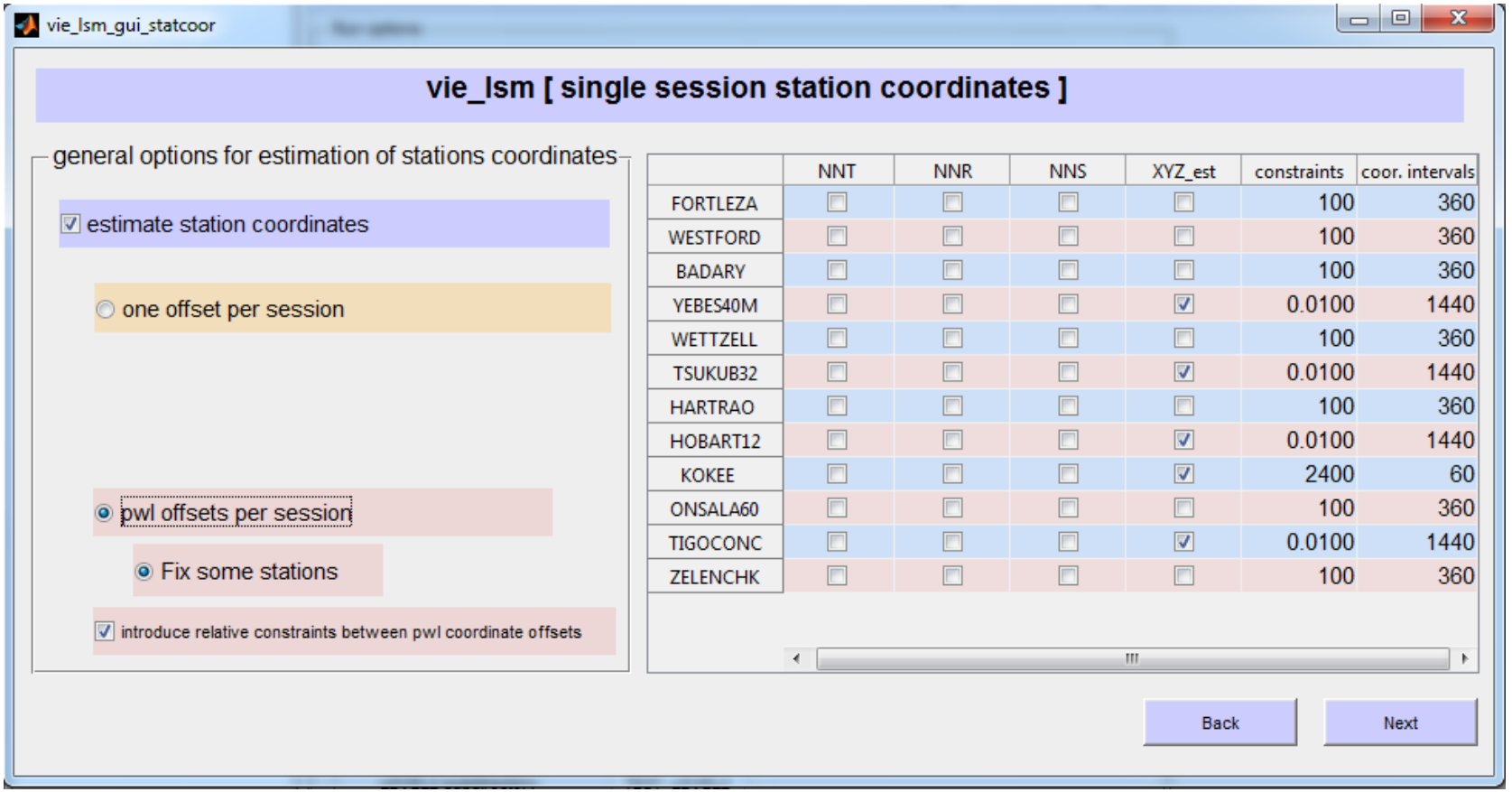
	ZWD coef.	NGR rel. coef.	EGR rel. coef.	NGR abs. coef.	EGR abs. coef.	ZWD int.	NGR int.	EGR int.	est. ZWD	est. NGR	est. EGR
FORTLEZA	0.7000	2	2	1	1	30	180	180	☑	☑	☑
WESTFORD	0.7000	2	2	1	1	30	180	180	☑	☑	☑
BADARY	0.7000	2	2	1	1	30	180	180	☑	☑	☑
YEBES40M	0.7000	2	2	1	1	30	180	180	☑	☑	☑
WETTZELL	0.7000	2	2	1	1	30	180	180	☑	☑	☑
TSUKUB32	0.7000	2	2	1	1	30	180	180	☑	☑	☑
HARTRAO	0.7000	2	2	1	1	30	180	180	☑	☑	☑
HOBART12	0.7000	2	2	1	1	30	180	180	☑	☑	☑
KOKEE	0.7000	2	2	1	1	30	180	180	☑	☑	☑

TRF antenna coordinates

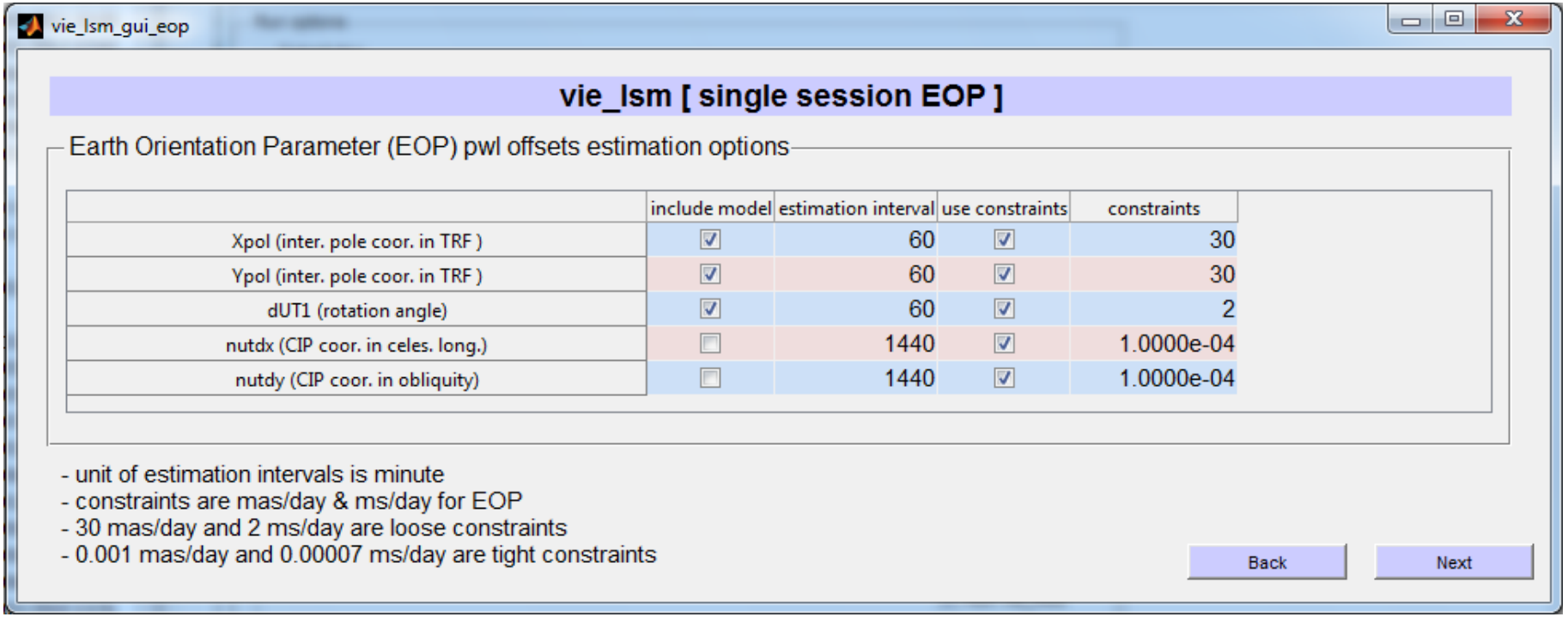


	NNT	NNR	NNS	XYZ_est	constraints	coor. intervals
FORTLEZA	☑	☑	☐	☑	100	360
WESTFORD	☑	☑	☐	☑	100	360
BADARY	☑	☑	☐	☑	100	360
YEBES40M	☐	☐	☐	☑	100	360
WETTZELL	☑	☑	☐	☑	100	360
TSUKUB32	☐	☐	☐	☑	100	360
HARTRAO	☑	☑	☐	☑	100	360
HOBART12	☐	☐	☐	☑	100	360
KOKEE	☑	☑	☐	☑	100	360
ONSALA60	☑	☑	☐	☑	100	360
TIGOCONC	☐	☐	☐	☑	100	360
ZELENCHK	☑	☑	☐	☑	100	360

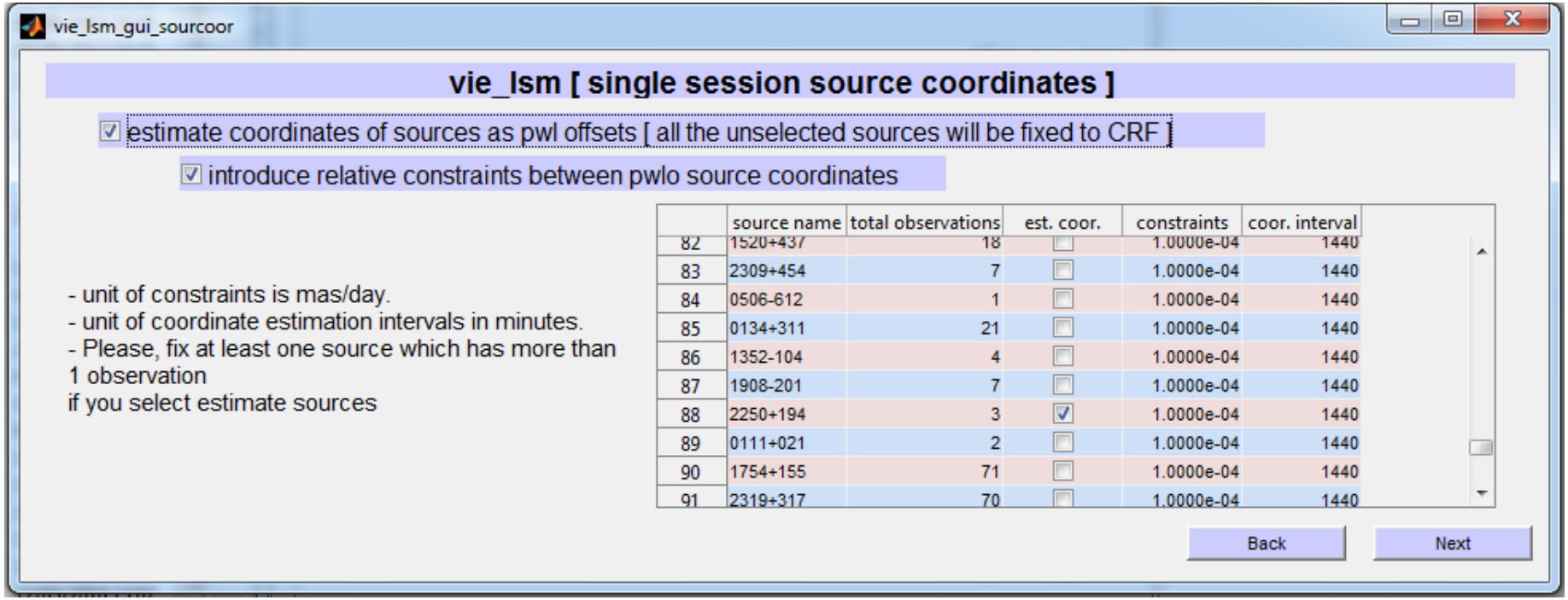
TRF antenna coordinates



EOP


vie_lsm_gui_eop
vie_lsm [single session EOP]
Earth Orientation Parameter (EOP) pwl offsets estimation options
include model
estimation interval
use constraints
constraints
Xpol (inter. pole coor. in TRF)
60
30
Ypol (inter. pole coor. in TRF)
60
30
dUT1 (rotation angle)
60
2
nutdx (CIP coor. in celes. long.)
1440
1.0000e-04
nutdy (CIP coor. in obliquity)
1440
1.0000e-04
- unit of estimation intervals is minute
- constraints are mas/day & ms/day for EOP
- 30 mas/day and 2 ms/day are loose constraints
- 0.001 mas/day and 0.00007 ms/day are tight constraints
Back
Next

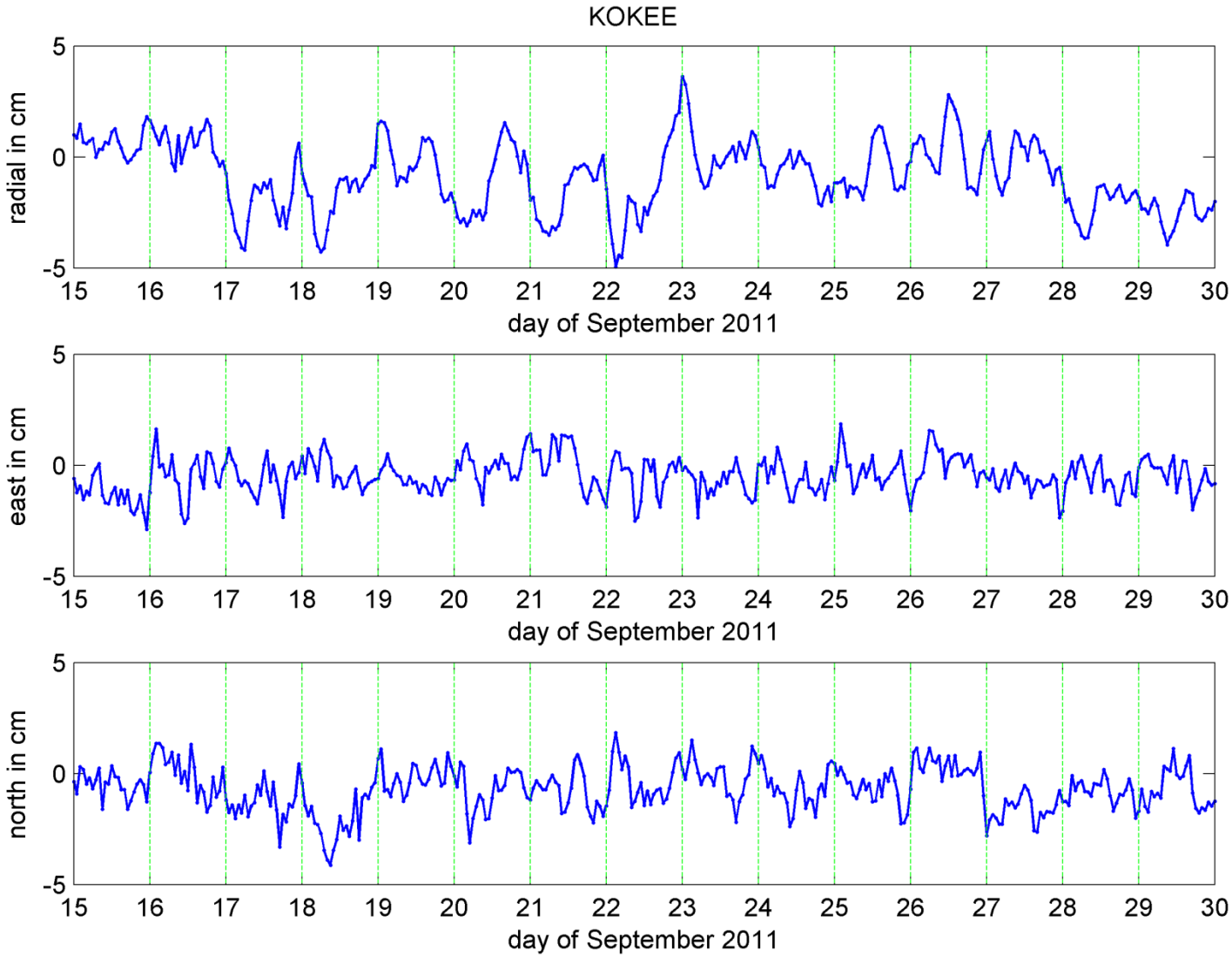
CRF source coordinates



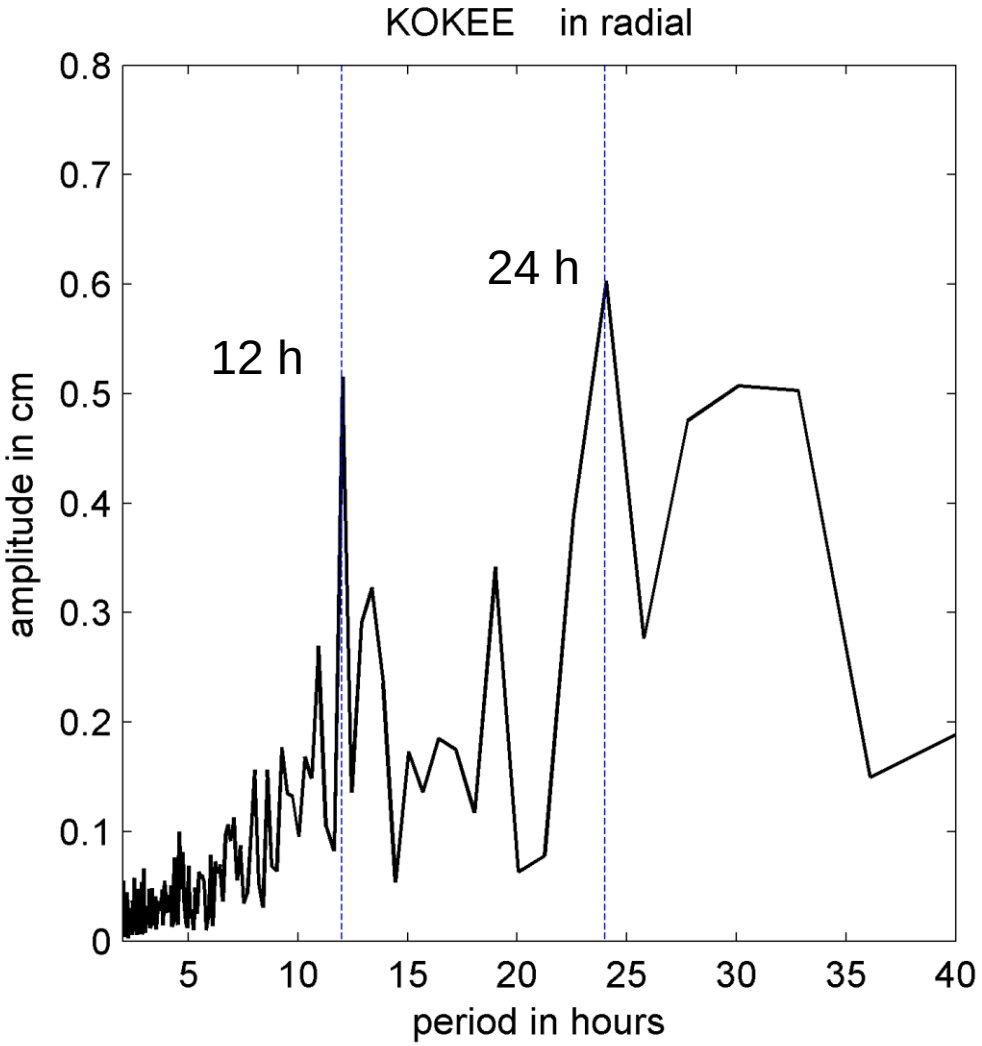
Conclusions

- vie_lsm corrects clock breaks and detects outlier observations.
- vie_lsm provides SINEX input and datum free normal equations for global solutions (vie_glob).
- CPWLO estimates of VieVS are in a good agreement with those derived from other space geodetic techniques.
- Tidal motions of the antenna TRF positions on sub-daily resolution (e.g. 1 hour during CONT11) can be unveiled accurately with VieVS.

CONT11


KOKEE
radial in cm
east in cm
north in cm
5
0
-5
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
day of September 2011

Fourier spectra of the hourly Kokee TRF coordinates



CONT11

Thank you so much
for your attention!