

Vie_LSM and Vie_LSM_scan (version 2.1)

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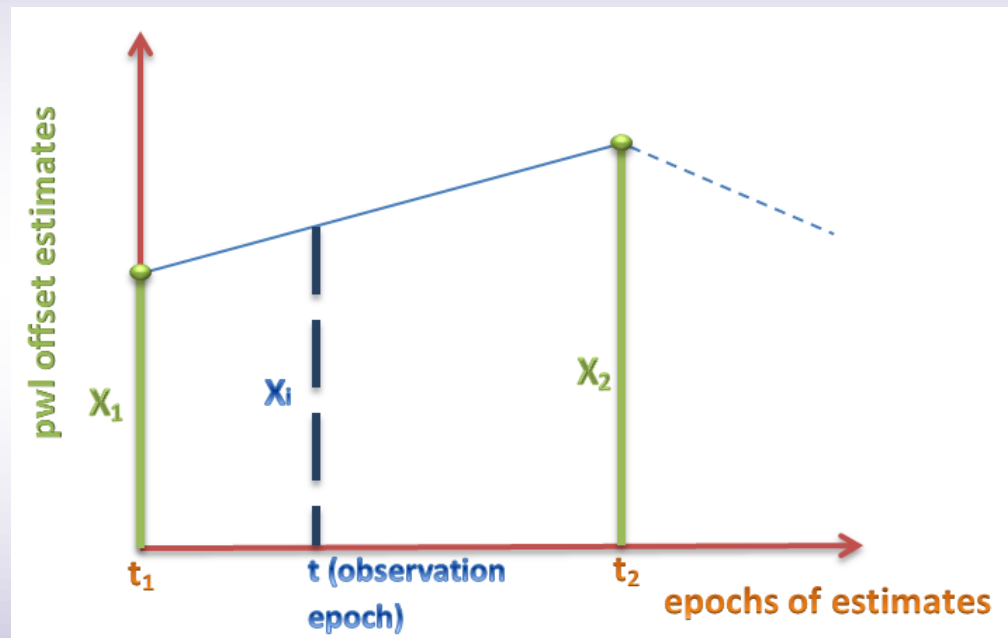
Introduction

- 🐶 “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/day²), 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 (declinations in mas and right ascensions in ms) 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

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

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

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

$$A = \begin{bmatrix} A(1).sm & \cdots & A(15).sm \end{bmatrix} \quad \rightarrow \quad \text{design matrix of real observation equations}$$

$$H = \begin{bmatrix} H(1).sm & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & H(15).sm \end{bmatrix} \quad \rightarrow \quad \text{design matrix of pseudo-observation equations (constraints)}$$

$$N = \begin{bmatrix} A^T P A + H^T P_H H & C^T \\ C & 0 \end{bmatrix} \quad b = \begin{bmatrix} A^T P o c + H^T P_H o c h \\ b_c \end{bmatrix}$$

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

parameter vector
(estimates)

$$x = N^{-1} b \quad m_0 = (v^T P v + v_H^T P_H v_H) / (n_{obs} + n_{constr} - n_{unk})$$

$$K_x = m_0 N^{-1} \quad \rightarrow \quad \text{variance-covariance matrix of the estimates}$$

Estimation Settings

The screenshot displays the 'Vienna VLBI Software 2.1' interface. The 'Estimation' menu is active, showing the 'VieVS estimation settings' dialog. The 'First solution' section is highlighted with a red box, containing the following options:

- ☒ 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

The 'Main solution' section is also highlighted with a red box, containing the following options:

- ☒ Run main solution (parameter estimation)
- ☒ Simple outlier test ($c * m0$)
- ☐ Normal outlier test ($c * m0 * \sqrt{qvv}$)
- ☒ Estimate parameters (otherwise: only N matrix created)
- Write all parameters to ASCII file
- ☒ Allow for stationwise and sourcewise parameterization for each session

A green box highlights the 'Simple outlier test' section, showing a value of 5 in the 'c' field. A blue arrow points from this field to the 'Outlier directory' field in the 'Outlier file' section of the 'Set input files' dialog.

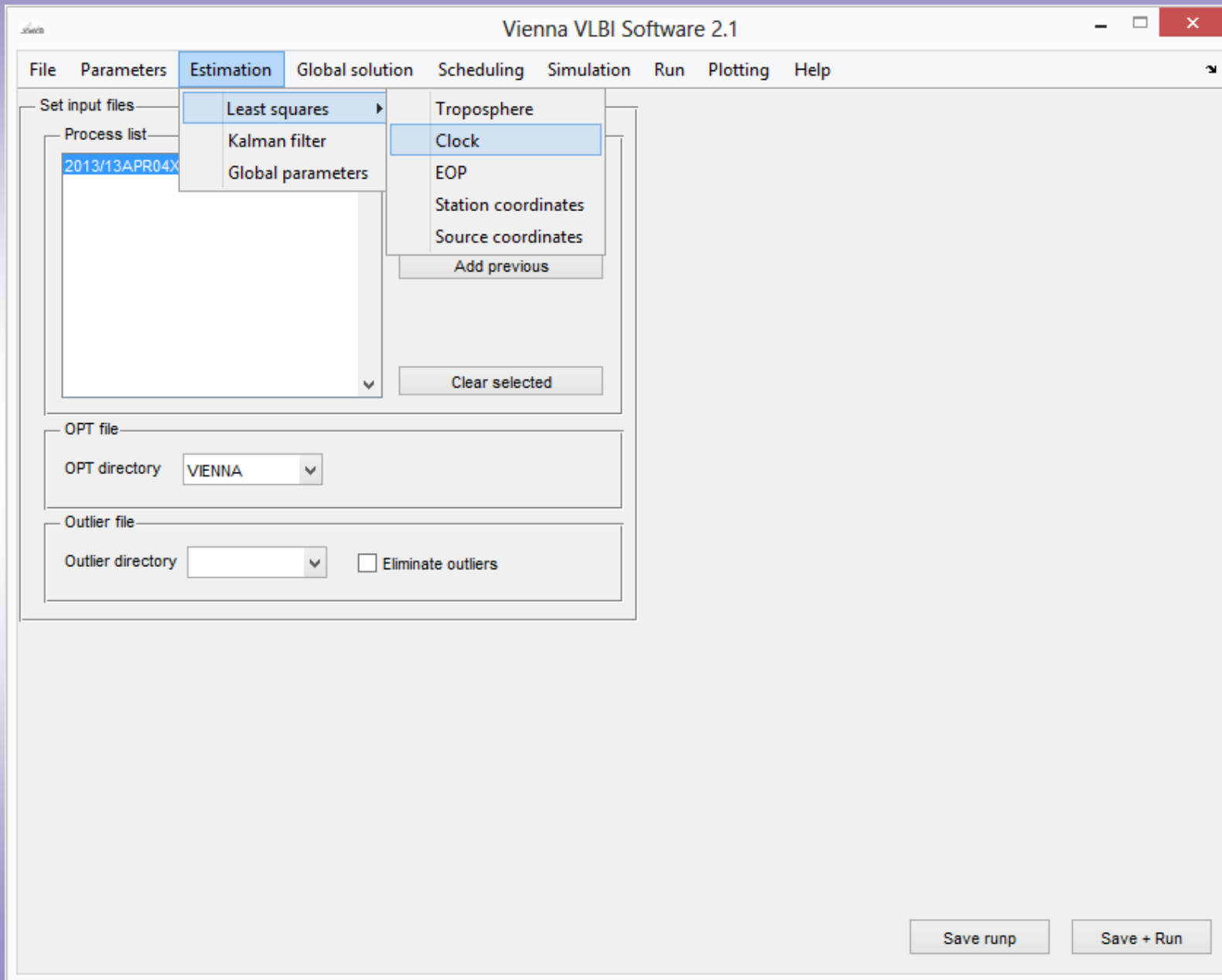
The 'Set input files' dialog shows a 'Process list' table with the following data:

Station	Source	Time
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

The 'Outlier file' section is highlighted with a green box, showing the 'Outlier directory' field and the 'Eliminate outliers' checkbox, which is checked.

The first solution is meant to remove large clock offsets (and rates and quadratic terms) for numerical reasons. (Clock offsets can be several kilometers.)

Parametrization for least squares



VLBI clock error

$$\Delta\tau_{clk}^{poly}(t) = \beta_0 + \beta_1(t-t_0) + \beta_2(t-t_0)^2 \rightarrow \text{quadratic polynomial for each clock}$$

$$\Delta\tau_{clk}^{CPWLO}(t) = x_1 + \frac{t-t_1}{t_2-t_1}(x_2-x_1) \rightarrow \text{CPWLO for each clock e.g. at each UTC integer hour (t}_1 \text{ and t}_2\text{)}$$

$$\Delta\tau_{clk}(t) = \Delta\tau_{clk}^{poly}(t) + \Delta\tau_{clk}^{CPWLO}(t) \rightarrow \text{total clock error at epoch t}$$

Parametrization for relative clock errors

Vienna VLBI Software 2.1

File Parameters Estimation Global solution Scheduling Simulation 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]

☒ introduce relative constraints between pwl clock offsets

Clock constraints [cm] after 60 minutes

```

CLOCK REFERENCE:
WETTZELL

CLOCK BREAKS: 0
STATIONS TO BE EXCLUDED: 0
BASELINES TO BE EXCLUDED: 0
SOURCES TO BE EXCLUDED: 0

#Outliers!
#Benedikt Soja 2013-04-20

# example
# =====
# CLOCK REFERENCE:
# WETTZELL
#
# CLOCK BREAKS: 2
# BADARY      55454.4
# WETTZELL     13369
#
# STATIONS TO BE EXCLUDED: 1
# MATERA
#
# BASELINES TO BE EXCLUDED: 3
# WETTZELL ZELENCHK
# WETTZELL ZELENCHK
# BADARY   ZELENCHK
#
# SOURCES TO BE EXCLUDED: 1
# 1936+095
    
```

This combination adds relative constraints on the clock offsets. Actually, observation equations are added to the design matrix which tell that the difference between two adjacent piecewise linear clock offsets is $\text{zero} \pm \text{a certain standard deviation } \sigma$. (These constraints are mainly important to bridge gaps without observations to avoid singularity of the normal equation system.)

Save runp Save + Run

Troposphere delay

$$\Delta\tau_{trop} = 10^{-6} \int_0^{H_{trop}} [N_h(s) + N_w(s)] ds$$

$$\Delta\tau_{trop}(\alpha, \varepsilon) = ZHD m_h(\varepsilon) + ZWD m_w(\varepsilon) + m_w(\varepsilon) \cot(\varepsilon) [G_n \cos(\alpha) + G_e \sin(\alpha)]$$

reduced from
observations a
priori to the
adjustment

estimated

estimated

estimated

Parametrization for ZWD and gradients

Vienna VLBI Software 2.1

File Parameters Estimation Global solution Scheduling Simulation Run Plotting Help

Troposphere estimation (least squares)

Zenith wet delays

☒ Estimate zenith wet delays

ZWD interval [min] 60

☒ introduce relative constraints between pwl zenith wet delay offsets

ZWD constraints [cm] 1.5 after 60 minutes

Gradients

☒ Estimate north gradients

NGR interval [min] 360

☒ introduce relative constraints between pwl NGR offsets

NGR constraints [cm] 0.05 after 360 minutes

☐ introduce absolute constraints between pwl NGR offsets

NGR abs. constr. [cm] 0.1

☒ Estimate east gradients

EGR interval [min] 360

☒ introduce relative constraints between pwl EGR offsets

EGR constraints [cm] 0.05 after 360 minutes

☐ introduce absolute constraints between pwl EGR offsets

EGR abs. constr. [cm] 0.1

Save runp Save + Run

Parametrization for EOP

Vienna VLBI Software 2.1

File Parameters Estimation Global solution Scheduling Simulation Run Plotting Help

EOP estimation (least squares)

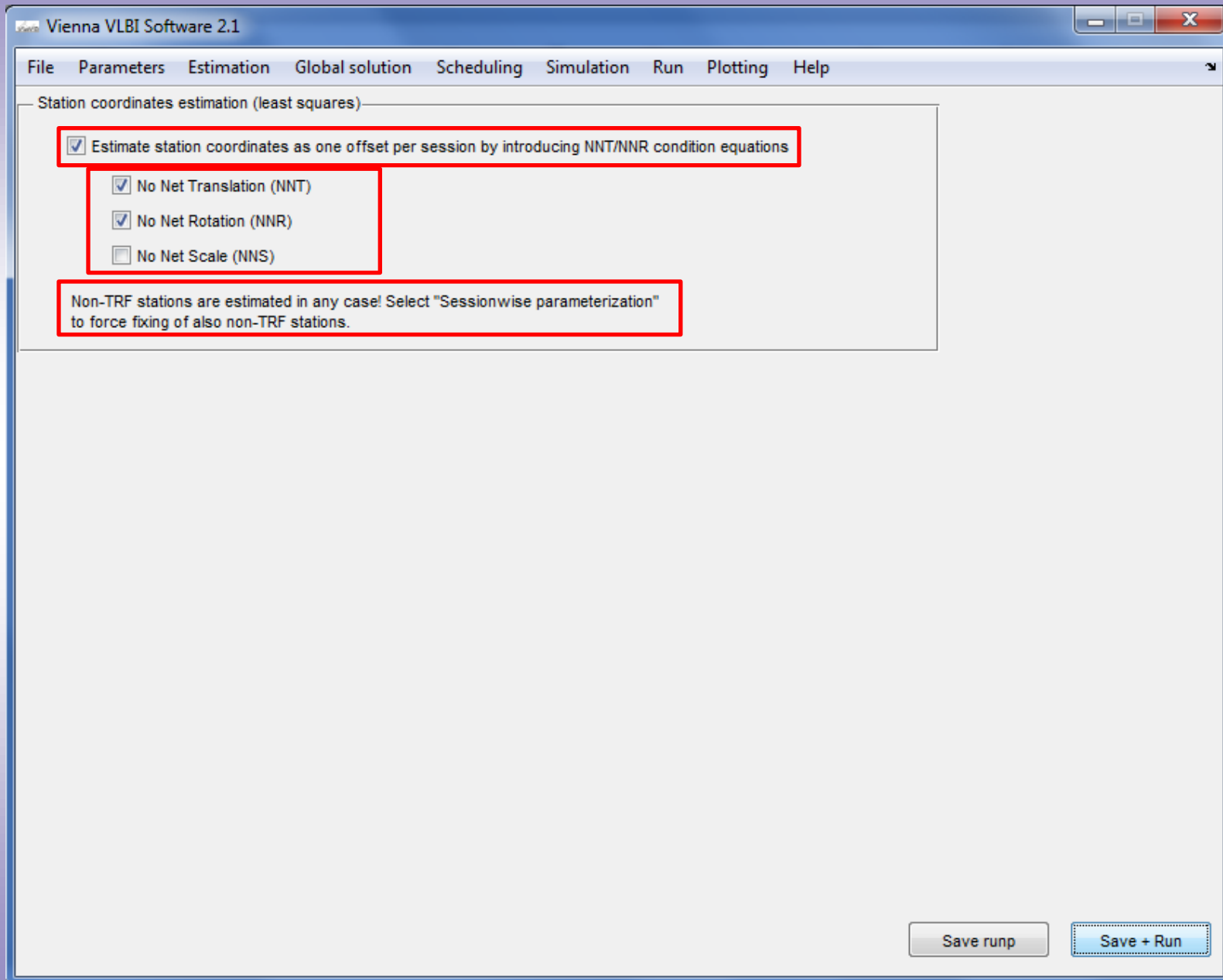
	estimation interval [min]	relative		
<input checked="" type="checkbox"/> Estimate Xpol (inter. pole coord. in TRF)	1440	<input checked="" type="checkbox"/> constraints [mas]	1.0e-4	after 1440 minutes
<input checked="" type="checkbox"/> Estimate Ypol (inter. pole coord. in TRF)	1440	<input checked="" type="checkbox"/> constraints [mas]	1.0e-4	after 1440 minutes
<input checked="" type="checkbox"/> Estimate dUT1 (rotation angle)	1440	<input checked="" type="checkbox"/> constraints [mas]	1.0e-4	after 1440 minutes
<input checked="" type="checkbox"/> Estimate nutdx (CIP coord. in celes. long.)	1440	<input checked="" type="checkbox"/> constraints [mas]	1.0e-4	after 1440 minutes
<input checked="" type="checkbox"/> Estimate nutdy (CIP coord. in obliquity)	1440	<input checked="" type="checkbox"/> constraints [mas]	1.0e-4	after 1440 minutes

Save runp Save + Run

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 $1\text{e-}4$ 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.

Parametrization for Station Coordinates



Parametrization for Source Coordinates

Vienna VLBI Software 2.1

File Parameters Estimation Global solution Scheduling Simulation Run Plotting Help

Source estimation (least squares)

☒ Estimate source coordinates as pwl offsets

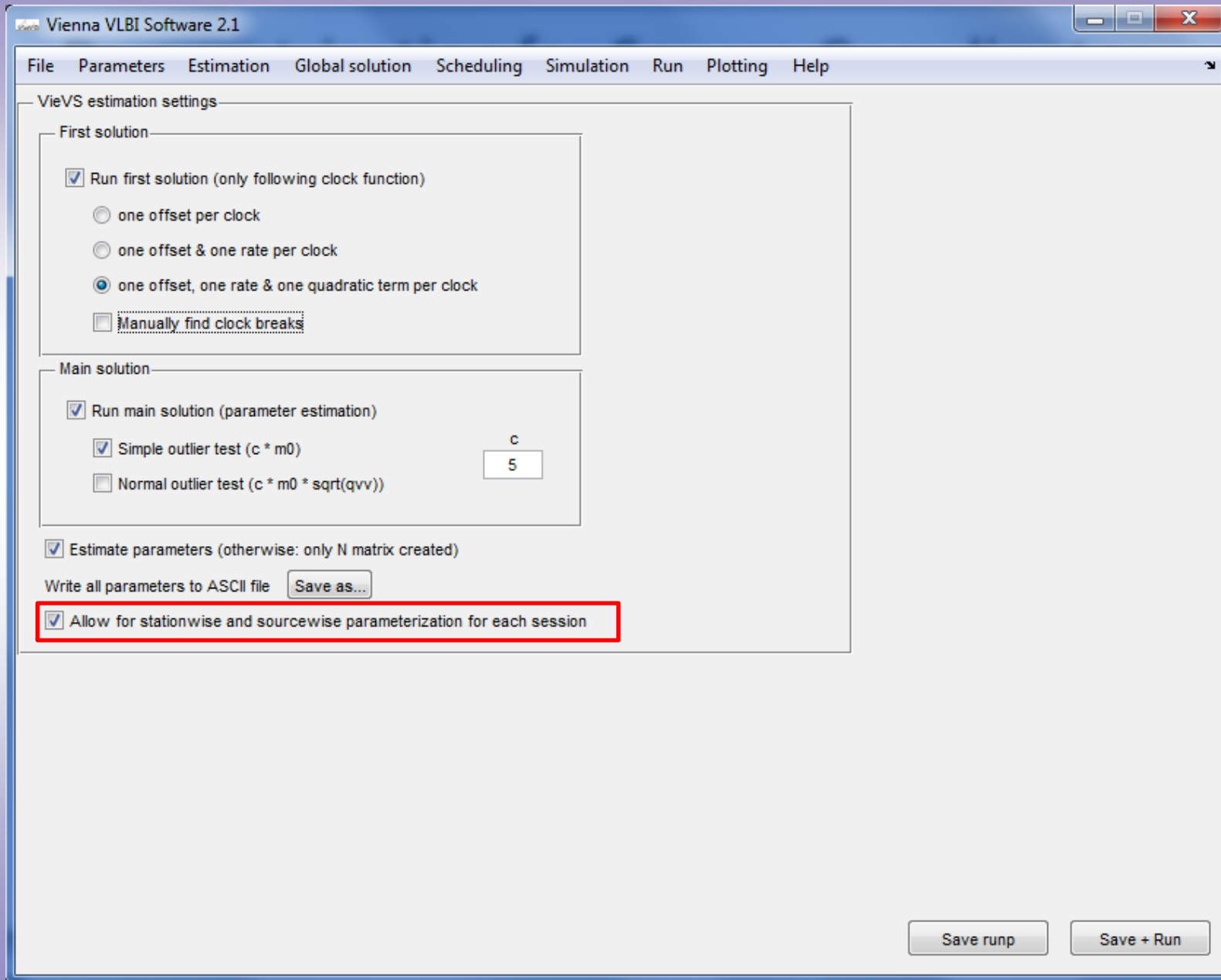
estimation interval [min] 1440

☒ relative constraints [mas] 1.0e-4 after 1440 minutes

Only non-CRF sources are estimated if this checkbox is ticked (select "Sessionwise parameterization" if you want otherwise...)

Save runp Save + Run

Session-wise parameterization



Session-wise parameterization

via_lsm [single session first solution]

parameterization for removing large clock errors

☒ apply first basic solution (only with clock function)

☐ one offset per clock

☐ one offset & one rate per clock

☒ one offset, one rate, & one quadratic term per clock

☒ use clock breaks (From OPT file)

reference clock for the first solution

WETTZELL

TSUKUB32

WETTZELL

SVETLOE

ZELENCHK

ONSALA60

NYALES20

HARTRAO

KOKEE

WESTFORD

MEDICINA

TIGOCONC

main solution

☒ apply main solution

coefficient

☒ simple outlier test [coefficient * mo]

5

☐ basic outlier test [coefficient * mo *sqrt(qw)]

clock/s that have breaks in the session

ZELENCHK

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Session-wise parameterization

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 centimeters
E.g. 1.3 cm after 1 hour is relatively loose.

	clock constraints	clock interval	reference clock
TSUKUB32	1.3000	60	<input type="checkbox"/>
WETTZELL	1.3000	60	<input checked="" type="checkbox"/>
SVETLOE	1.3000	60	<input type="checkbox"/>
ZELENCHK	1.3000	60	<input type="checkbox"/>
ONSALA60	1.3000	60	<input type="checkbox"/>
NYALES20	1.3000	60	<input type="checkbox"/>
HARTRAO	1.3000	60	<input type="checkbox"/>
KOKEE	1.3000	60	<input type="checkbox"/>
WESTFORD	1.3000	60	<input type="checkbox"/>
MEDICINA	1.3000	60	<input type="checkbox"/>
TIGOCONG	1.3000	60	<input type="checkbox"/>

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vie_lsm [single session troposphere]

apply relative constraints between tropospheric offset estimates

☒ introduce RELATIVE CONSTRAINTS between pwl ZENITH WET DELAY offsets

☒ introduce REALTIVE CONSTRAINTS between pwl tropo. NORTH GRADIENT offsets

☒ introduce RELATIVE CONSTRAINTS between pwl tropo. EAST GRADIENT offsets

☐ introduce ABSOLUTE CONSTRAINTS between pwl tropo. NORTH GRADIENT offsets

☐ introduce ABSOLUTE CONSTRAINTS between pwl tropo. EAST GRADIENT offsets

- unit of estimation intervals is minute.

- unit of ZWD relative constraints is cm e.g. 1.5 cm after 1 hour is relatively loose.

- unit of NGR & EGR relative constraints is cm, e.g. 0.05 cm after 6 hours is relatively loose.

- unit of NGR & EGR absolute constraints is cm, e.g. 0.1 cm absolutely loose.

	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
TSUKUB32	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
WETTZELL	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
SVETLOE	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ZELENCHK	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ONSALA60	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
NYALES20	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
HARTRAO	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
KOKEE	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
WESTFORD	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
MEDICINA	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

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	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
TSUKUB32	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
WETTZELL	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
SVETLOE	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ZELENCHK	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ONSALA60	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
NYALES20	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
HARTRAO	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
KOKEE	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
WESTFORD	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
MEDICINA	1.5000	0.0500	0.0500	0.1000	0.1000	60	360	360	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Session-wise parameterization

Case 1: NNT/NNR (one coordinate offset per session)

vie_lsm_gui_statcoor

vie_lsm [single session station coordinates]

general options for estimation of stations coordinates

☒ estimate station coordinates

☒ one offset per session

☒ NNT/NNR

☐ Fix some stations

☐ pwl offsets per session

	NNT	NNR	NNS	XYZ_est	constraints	coord. intervals
TSUKUB32	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
WETTZELL	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
SVETLOE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
ZELENCHK	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
ONSALA60	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
NYALES20	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
HARTRAO	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
KOKEE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
WESTFORD	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
MEDICINA	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360

Unit of TRF relative constraints is cm, e.g. 10 cm after 6 hours is relatively loose.

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Session-wise parameterization

Case 2: Fix some station coordinates (one coordinate offset per session)

vie_lsm_gui_statcoor

vie_lsm [single session station coordinates]

general options for estimation of stations coordinates

☒ estimate station coordinates

☒ one offset per session

☐ NNT/NNR

☒ Fix some stations

☐ pwl offsets per session

	NNT	NNR	NNS	XYZ_est	constraints	coord. intervals
TSUKUB32	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
WETTZELL	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10	360
SVETLOE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
ZELENCHK	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
ONSALA60	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
NYALES20	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10	360
HARTRAO	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
KOKEE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10	360
WESTFORD	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10	360
MEDICINA	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
TIGOCONG	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360

Unit of TRF relative constraints is cm, e.g. 10 cm after 6 hours is relatively loose.

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Session-wise parameterization

Case 3: Fix some station coordinates (CPWLO coordinates)

vie_lsm_gui_statcoor

vie_lsm [single session station coordinates]

general options for estimation of stations coordinates

☒ estimate station coordinates

☐ one offset per session

☒ pwl offsets per session

☒ Fix some stations

☒ introduce relative constraints between pwl coordinate offsets

	NNT	NNR	NNS	XYZ_est	constraints	coord. intervals
TSUKUB32	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
WETTZELL	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10	360
SVETLOE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
ZELENCHK	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
ONSALA60	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
NYALES20	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10	360
HARTRAO	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
KOKEE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10	360
WESTFORD	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10	360
MEDICINA	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360
TIGOCANC	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	10	360

Unit of TRF relative constraints is cm, e.g. 10 cm after 6 hours is relatively loose.

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Session-wise parameterization

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 coord. in TRF)	<input checked="" type="checkbox"/>	1440	<input checked="" type="checkbox"/>	1.0000e-04
Ypol (inter. pole coord. in TRF)	<input checked="" type="checkbox"/>	1440	<input checked="" type="checkbox"/>	1.0000e-04
dUT1 (rotation angle)	<input checked="" type="checkbox"/>	1440	<input checked="" type="checkbox"/>	1.0000e-04
nutdx (CIP coord. in celes. long.)	<input checked="" type="checkbox"/>	1440	<input checked="" type="checkbox"/>	1.0000e-04
nutdy (CIP coord. in obliquity)	<input checked="" type="checkbox"/>	1440	<input checked="" type="checkbox"/>	1.0000e-04

- unit of estimation intervals is minute
- constraints are mas for EOP
- 2 mas after 1 hour is relatively loose constraints for EOP

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Session-wise parameterization

vie_lsm_gui_sourcoor

vie_lsm [single session source coordinates]

☒ estimate coordinates of sources as pwl offsets [all the unselected sources will be fixed to CRF]

☒ introduce relative constraints between pwlo source coordinates

- unit of constraints is mas.
- unit of coordinate estimation intervals in minutes.
- Please, fix at least one source which has more than 1 observation
if you select estimate sources
- Non-CRF sources will be estimated as default.

	source name	total observations	est. coord.	constraints	coord. interval
34	1044+719	80	<input type="checkbox"/>	1.0000e-04	1440
35	1308+326	4	<input type="checkbox"/>	1.0000e-04	1440
36	2201+315	35	<input type="checkbox"/>	1.0000e-04	1440
37	0656+082	7	<input type="checkbox"/>	1.0000e-04	1440
38	1034-293	41	<input type="checkbox"/>	1.0000e-04	1440
39	1124-186	110	<input checked="" type="checkbox"/>	1.0000e-04	1440
40	1219+044	6	<input type="checkbox"/>	1.0000e-04	1440
41	3C274	77	<input type="checkbox"/>	1.0000e-04	1440
42	1351-018	8	<input type="checkbox"/>	1.0000e-04	1440
43	0106+013	38	<input type="checkbox"/>	1.0000e-04	1440
44	0749+540	35	<input type="checkbox"/>	1.0000e-04	1440
45	0805+410	3	<input type="checkbox"/>	1.0000e-04	1440
46	0743+259	36	<input type="checkbox"/>	1.0000e-04	1440
47	2243-123	23	<input type="checkbox"/>	1.0000e-04	1440
48	3C371	90	<input type="checkbox"/>	1.0000e-04	1440
49	1739+522	13	<input checked="" type="checkbox"/>	1.0000e-04	1440
50	1954-388	14	<input type="checkbox"/>	1.0000e-04	1440
51	1156+295	26	<input type="checkbox"/>	1.0000e-04	1440
52	2121+053	49	<input type="checkbox"/>	1.0000e-04	1440

Back Next

Session-wise parameterization

vie_lsm_gui_global

vie_lsm [single session output]

☒ **Estimate parameters according to the options in previous GUIs**

☒ **Prepare N_global and b_global for global solution**

No parameters are reduced. (Reduction can be done in VIE_GLOB.) Constraints according to previous GUIs. Conditions on station coordinates are removed. N and b will be stored in DATA/LEVEL2/

☒ **write data into SINEX file (DATA/SNX/)**

parameters	include into SINEX file	reduce from N_sinex	parameters	include into SINEX file	reduce from N_sinex
clock parameters		<input checked="" type="radio"/>	source coordinates		
zenith wet delay	<input checked="" type="radio"/>	<input type="radio"/>	station coordinates	<input checked="" type="radio"/>	
tropospheric gradients	<input checked="" type="radio"/>	<input type="radio"/>	EOP	<input checked="" type="radio"/>	<input type="radio"/>

Add extra parameters to the N matrix

☐ source coordinates (all sources - datum free) **ATTENTION! Don't estimate sources from single session if you want to store them in the N matrix!!!**

☐ station velocities:

Back Finish

vie_lsm scan-wise update

Vienna VLBI Software 2.1

File Parameters Estimation Global solution Scheduling Simulation Run Plotting Help

Run options

Scheduling

☐ Run vie_sched

Simulation

☐ Run vie_sim

VieVS

☒ one subdirectory (recommended)

☐ different subdirectories

vie_init -> vie_mod -> vie_lsm ->

vie_glob ->

☒ Run vie_init

☒ Run vie_mod

☒ Run vie_lsm scanwise update ☐ Run vie_lsm

☐ Run parallel Number of cores

Info: Faster for >1 sessions, but
Command Window output is disarranged!

Global solution

Path to LEVEL2 data

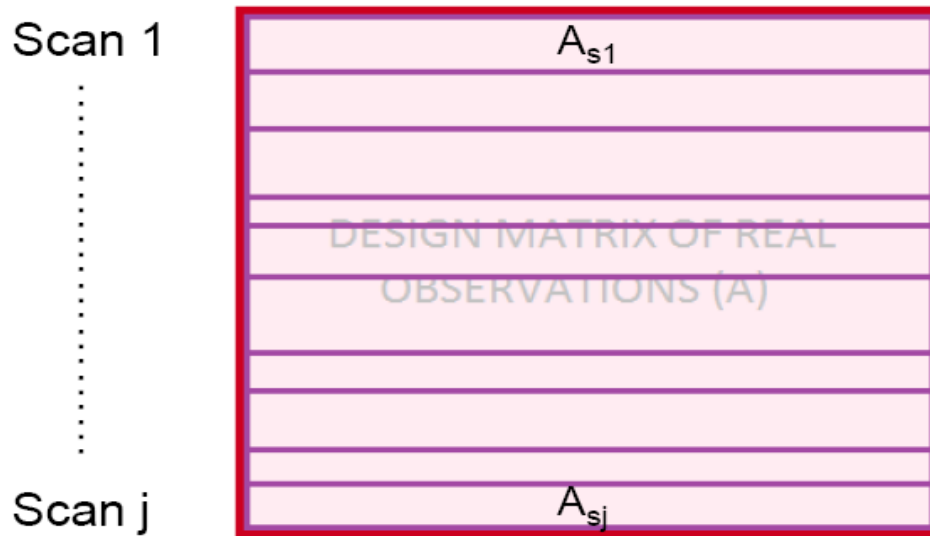
LEVEL2 subdirectory

Output directory for vie_glob

☐ Run vie_glob

Scan-wise update of normal equation system

1 A-matrix per scan



j : number of scans in the session

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

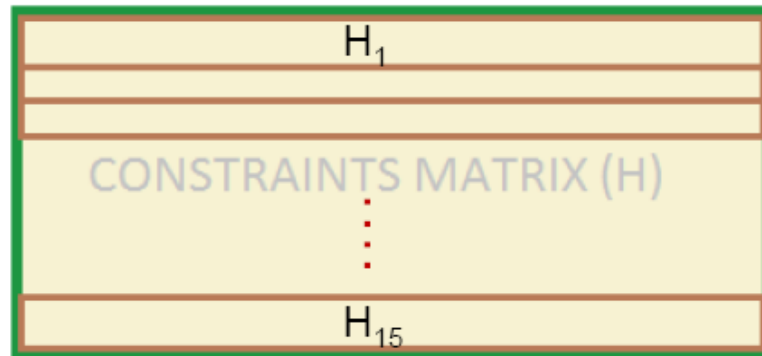
$$N_A = N_{s1} + N_{s2} + \dots + N_{sj}$$

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

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

Scan-wise update of normal equation system

Same procedure with H matrix: 15 H-matrixes



$$N_1 = H_1^T \cdot P_h \cdot H_1$$

$$N_H = N_1 + N_2 + \dots + N_{15}$$

$$b_1 = H_1^T \cdot P_{h_1} \cdot oc_1$$

$$b_H = b_1 + b_2 + \dots + b_{15}$$

$$N = A^T \cdot P \cdot A \quad \rightarrow \quad N = N_A + N_H$$

$$b = A^T \cdot P \cdot oc \quad \rightarrow \quad b = b_A + b_H$$

$$x = N^{-1} \cdot b$$

Command window – vie_lsm

```
vie_mod successfully finished!
```

```
-----  
|                               Welcome to VIE_LSM!!!!                               |  
-----
```

```
number of scans : 1151  
number of antennas : 11  
number of sources : 76  
number of obs. : 9917
```

```
2. CREATING DEFAULT OPTIONS
```

```
3. FORMING THE WEIGHT MATRIX OF THE OBSERVATIONS "Pobserv"
```

```
apriori std. dev. of unit weight. : 1.1217
```

```
obs. of the antenna TSUKUB32 : 1957  
obs. of the antenna WETTZELL : 2326  
obs. of the antenna SVETLOE : 2457  
obs. of the antenna ZELENCHK : 1420  
obs. of the antenna ONSALA60 : 2465  
obs. of the antenna NYALES20 : 2354  
obs. of the antenna HARTRAO : 1073  
obs. of the antenna KOKEE : 1456  
obs. of the antenna WESTFORD : 1769  
obs. of the antenna MEDICINA : 2269  
obs. of the antenna TIGOCONC : 288
```

```
4. FORMING THE REDUCED OBSERVATION VECTOR "oc_observ"
```

```
clock WETTZELL is selected as the ref. clock for the first solution
```

```
chi-squared of first solution: 23.3393
```

```
5. FORMING THE DESIGN MATRICES "A(i).sm" ...
```

```
6. FORMING THE CONSTRAIN MATRIX and WEIGHT MATRIX OF CONSTRAINTS
```

```
7. ESTIMATING THE PARAMETERS WITH LEAST SQUARES
```

```
!!! some or all station coordinates are not estimated (selected as fixed)!!!
```

```
clock WETTZELL is selected as the ref. clock for the main solution
```

```
chi-squared of main solution vTPv/degOfFreedom: 1.2136
```

Command window – vie_lsm

```
-----  
detecting outliers  
num. of outliers : 2  
writing outliers to file ../DATA/OUTLIER/2008/08AUG12XA_N004.OUT  
total 2 outlier observations are found but NOT eliminated  
-----
```





```
total number of estimated parameters: 735  
total clock offsets: 238  
total rate and quad. terms of clock funct.: 20  
total zenith wet delay offsets: 263  
total tropo. north gradients: 53  
total tropo. east gradients: 53  
total pole coor. (x-pol) offsets: 2  
total pole coor. (y-pol) offsets: 2  
total dUT1 offsets: 2  
total celestial pole (nutation dx) offsets: 2  
total celestial pole (nutation dy) offsets: 2  
total right ascension offsets of sources : 4  
total declination offsets of sources : 4  
antenna coor. dx offsets: 30  
antenna coor. dy offsets: 30  
antenna coor. dz offsets: 30  
-----
```

```
estimated parameters are saved as ../VieVS/DATA/LEVEL3/forworkshop/x_08AUG12XA_N004.mat  
estimation options are saved as ../VieVS/DATA/LEVEL3/forworkshop/opt_08AUG12XA_N004.mat  
normal equation matrix is saved as ../VieVS/DATA/LEVEL3/forworkshop/atpa_08AUG12XA_N004.mat  
right hand side vector is saved as ../VieVS/DATA/LEVEL3/forworkshop/atpl_08AUG12XA_N004.mat  
residuals are saved as ../VieVS/DATA/LEVEL3/forworkshop/res_08AUG12XA_N004.mat  
-----
```

```
Data for GLOBAL SOLUTION is saved as ../VieVS/DATA/LEVEL2/forworkshop/08AUG12XA_N004_an_glob.mat  
Data for GLOBAL SOLUTION is saved as ../VieVS/DATA/LEVEL2/forworkshop/08AUG12XA_N004_par_glob.mat  
Data for GLOBAL SOLUTION is saved as ../VieVS/DATA/LEVEL2/forworkshop/08AUG12XA_N004_Nb_glob.mat  
-----
```

```
Reduced N and b for SINEX output are saved in ../VieVS/DATA/LEVEL3/forworkshop/SINEX/
```

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.
-  Scan-wise update of normal equation system ensures a successful process of the future sessions with lots of observations.

Thank you so much
for your attention!