TECHNISCHE
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VIE_LSM

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Vienna

VieVS
Vienna VLBI Software

Introduction

- vie_lsm is a module of VieVS, which estimates geodetic parameters with least squares adjustment from VLBI observations.
- vie_lsm includes 31 + 7 (GUIs) functions.
- all estimated parameters (vie_lsm outputs) are in units of cm, mas, and ms.
- estimated parameters are:
  - quadratic polynomial coefficients of clocks (offset in cm, rate in cm/day, and quadratic term in cm/day^2) plus piecewise linear (pwl) offsets of clocks in cm,
  - zenith wet delay (ZWD) pwl offsets in cm,
  - troposphere north and east total gradients pwl offsets in cm,
  - Earth orientation parameters (EOPs) pwl offsets in mas and ms,
  - TRF coordinates of antennas in cm (pwl offsets or one offset per session),
  - CRF coordinates of sources as pwl offsets in mas .

vie_lsm inputs

- 'VieVS/DATA/LEVEL1/USER_DIR/fname_antenna.mat'
  - **antenna(8):** 8th antenna related information within the session. Antenna name (.name). If antenna do not exist in TRF catalogue (.in_trf = 0 “1”) then coordinates of the antenna are taken from NGS file, coordinates and velocities of antenas (.x, .y, .z, .vx, .vy, .vz, .epoch), antenna thermal deformations (.thermal), hydrostatic and wet VMF1 coefficients (.vm1), total number of observations of the antenna in the session (.numobs), antenna type (.axtyp), antenna axis offset (.offs), eccentricities (.ecc), …
  - **antenna(8).info:** auxiliary information related to the 8th antenna of the session. E.g. focus type (.focus), mounting type (.mount), …

Note: variable names, their units, default values and descriptions can be found in: ‘VieVS/DOC/VieVS_variables.pdf’

vie_lsm inputs

- 'VieVS/DATA/LEVEL1/USER_DIR/fname_parameter.mat'
  - **parameter.vie_init** : NOT used in vie_lsm.
  - **parameter.vie_mod** : NOT used in vie_lsm.
  - **parameter.eop** : NOT used in vie_lsm.
  - **parameter.lsmopt** : all parameterizations that is selected by the user via the GUIs of multi-session process
    - e.g. estimate troposphere total north gradients for **all antennas**! (.pw_ngr = 1"logical") for 360 minutes estimation interval (.int_ngr = 360) and impose 2 mm/day relatively loose constraints on the estimates (.constr_rel_ngr = 1"logical") (.coef_rel_ngr = 2). **Antenna specific** parameterizations are stored in the outputs of vie_lsm (opt_.stat(i).int_ngr = 360) and can only be specified in the GUIs of single session process.

Note: variable names, their units, default values and descriptions can be found in: 'VieVS/DOC/VieVS_variables.pdf'

vie_lsm inputs

- 'VieVS/DATA/LEVEL1/USER_DIR/fname_scan.mat'
  - **scan(10).stat(2)** : all values are due to the epoch of the scan. Station TRF coordinates (velocity plus tidal corrections introduced) (.x), temperature at the site (.temp), pressure (.pres), azimuth of observation (.az), zenith distance of the observation (.zd), zenith hydrostatic delay (.zdry), correction to the delay due to axis offset (.axkt), correction to the delay due to the thermal deformation of the antenna (.therm), partial derivatives of the delay w.r.t. antenna coordinates (.pantd), hydrostatic and wet MFs (.mfh, .mfw), cable delay (correction),…
  - **scan(10).space** : NOT used in vie_lsm.

Note: variable names, their units, default values and descriptions can be found in: 'VieVS/DOC/VieVS_variables.pdf'

vie_lsm inputs

- 'VieVS/DATA/LEVEL1/USER_DIR/fname_scan.mat'
  - **scan(456).obs(3)** : The values corresponds to the 3rd observation of the 456th scan. These are e.g. observed delay in seconds (.obs), standard deviation of the delay in seconds (.sig), computed delay in seconds (.com), the assigned number to the antennas within each session of the observation (.i1 = 3 and .i2 = 1), observed source number of the scan (.iso = 14), quality code of the delay (.q_code = 0 “0-9”), partial derivatives of the delay w.r.t. source coordinates (.psou = [pra pde]), w.r.t. nutation (.pnut = [pdX pdY]), w.r.t. pole coordinates in TRF and w.r.t. dUT1 (.ppol = [pdx pdy put]), w.r.t. first station TRF coordinates (.pstat1), …

Note: variable names, their units, default values and descriptions can be found in: ‘VieVS/DOC/VieVS_variables.pdf’

vie_lsm inputs

'VieVS/DATA/LEVEL1/USER_DIR/fname_sources.mat'

- **source(24)** : 24th source of the session. The variables stored in this structure array are: source name (.name), right ascension (.ra2000), and declination in radians (.de2000), if source includes in the CRF catalogue then .in_crf = 1 “0”. In case, .in_crf is 0 then source coordinates will be taken from the NGS file. Total number of observations to the source (.numobs) within the session, if the source is defining source of CRF catalogue or not (.def = 1”0”), …

Note: variable names, their units, default values and descriptions can be found in: ‘VieVS/DOC/VieVS_variables.pdf’

The models: A(i).sm, H(i).sm, Ph(i).sm, och(i).sv

Up to now the applied models are:

- pwl clock offsets … **A(1).sm [1], H(1).sm [1], Ph(1).sm [1/cm^2]**
- rate and quadratic terms of clock polynomials … **A(2).sm [day day^2]**
- pwl offsets of zenith wet delays … **A(3).sm [1], H(3).sm [1], Ph(3).sm [1/cm^2]**
- pwl offsets of troposphere north gradients … **A(4).sm [1], H(4).sm [1], Ph(4).sm [1/cm^2]**
- pwl offsets of troposphere east gradients … **A(5).sm [1], H(5).sm [1], Ph(5).sm [1/cm^2]**
- pwl offsets of polar motion coordinate in TRF along the Greenwich Meridian (X_{pol}) … **A(6).sm [cm/mas], H(6).sm [1], Ph(6).sm [1/mas^2]**
- pwl offsets of polar motion coordinate in TRF along the 270° meridian (Y_{pol}) … **A(7).sm [cm/mas], H(7).sm [1], Ph(7).sm [1/mas^2]**
- pwl offsets of Earth's rotation phase (UT1-UTC) … **A(8).sm [cm/mas], H(8).sm [1], Ph(8).sm [1/mas^2]**
- pwl offsets of celestial intermediate pole (CIP) coordinate in CRF along the obliquity of ecliptic (nutation in obliquity) (dX_{nut}) … **A(9).sm [cm/mas], H(9).sm [1], Ph(9).sm [1/mas^2]**
- pwl offsets of celestial intermediate pole (CIP) coordinate in CRF along the celestial longitude (nutation in celestial longitude) (dY_{nut}) … **A(10).sm [cm/mas], H(10).sm [1], Ph(10).sm [1/mas^2]**
- pwl offsets of right ascensions of sources in CRF … **A(11).sm [cm/mas], H(11).sm [1], Ph(11).sm [1/mas^2]**
- pwl offsets of declinations of sources in CRF … **A(12).sm [cm/mas], H(12).sm [1], Ph(12).sm [1/mas^2]**
- pwl offsets or one offset (optional) of VLBI antenna X coordinate in TRF … **A(13).sm [1], H(13).sm [1], Ph(13).sm [1/cm^2]**
- pwl offsets or one offset (optional) of VLBI antenna Y coordinate in TRF … **A(14).sm [1], H(14).sm [1], Ph(14).sm [1/cm^2]**
- pwl offsets or one offset (optional) of VLBI antenna Z coordinate in TRF … **A(15).sm [1], H(15).sm [1], Ph(15).sm [1/cm^2]**

Constraining the estimates: H(i).sm, Ph(i).sm

- weight matrix of observations (Pobserv) is a diagonal matrix and units are in $1/cm^2$. Since, the standard deviations of observations (m_{obs}) are so small, they are added 1 cm before weights are formed ($1/m_{obs}^2$). Currently, no down weighting is applied due to elevation angles of the observations.
- observation vector is in cm and pseudo-observation vectors (constraints on estimated parameters) “och(i).sv” are zero. Because all estimates constrained to zero with a large or a small standard deviation (loose or tight).

$\text{offset}(t+1) - \text{offset}(t) = 0 \pm m_{c\_rel}$ → relative constraints

Example:

(in case, m_{c_rel} = 30 mas/day then pwl X_pol offsets will be relatively loose)

(in case, m_{c_rel} = 0.001 mas/day then pwl X_pol offsets will be relatively tight)

$\text{offset}(t) = 0 \pm m_{c\_abs}$ → absolute constraints

Example:

(in case, m_{c_abs} = 2 mm/day then pwl troposphere east gradient offsets will be absolutely loose)

(in case, m_{c_abs} = 0.01 mm/day then pwl troposphere east gradient offsets will be absolutely tight)

Constraining the estimates: H(i).sm, Ph(i).sm

- $$H = \begin{bmatrix} H(1).sm & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & H(15).sm \end{bmatrix}$$; total constrain equations on the estimated parameters
- $$H(i).sm = \begin{bmatrix} 1 & -1 & 0 & \cdots & 0 & 0 \\ 0 & 1 & -1 & \cdots & 0 & 0 \\ 0 & 0 & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & 1 & -1 \end{bmatrix}$$; dimension : (k – 1 x k)
- $$P_H(\mathrm{i}).\mathrm{sm} = \begin{bmatrix} 1/{m_{1c\_rel}}^2 & 0 & \cdots & 0 \\ 0 & 1/{m_{2c\_rel}}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & 0 \\ 0 & 0 & \cdots & 1/{m_{(k-1)c\_rel}}^2 \end{bmatrix}$$; (k-1 x k-1)
- k : number of pwl offsets for the model i.
- k-1 : number of relative constrain equations on the pwl offsets of model i.

Concatenation of sub-matrices

- $\mathrm{A} = [A(1).sm \quad \ldots \quad A(15).sm]$
- $\mathrm{H} = \begin{bmatrix} H(1).sm & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & H(15).sm \end{bmatrix}$
- $\mathrm{N} = \begin{bmatrix} A^T PA + H^T P_H H & C^T \\ C & 0 \end{bmatrix}$
- $b = \begin{bmatrix} A^T P\ oc + H^T P_H\ och \\ b_c \end{bmatrix}$ b_c is a zero vector (dimension changes according to the options if NNT and NNR imposed then 6x1)
- $x = N^- b$
- $m_0 = (v^T P v + v_H^T P_H v_H)/(n_{obs} + n_{constr} - n_{unk})$
- $K_X = m_0 N^-$

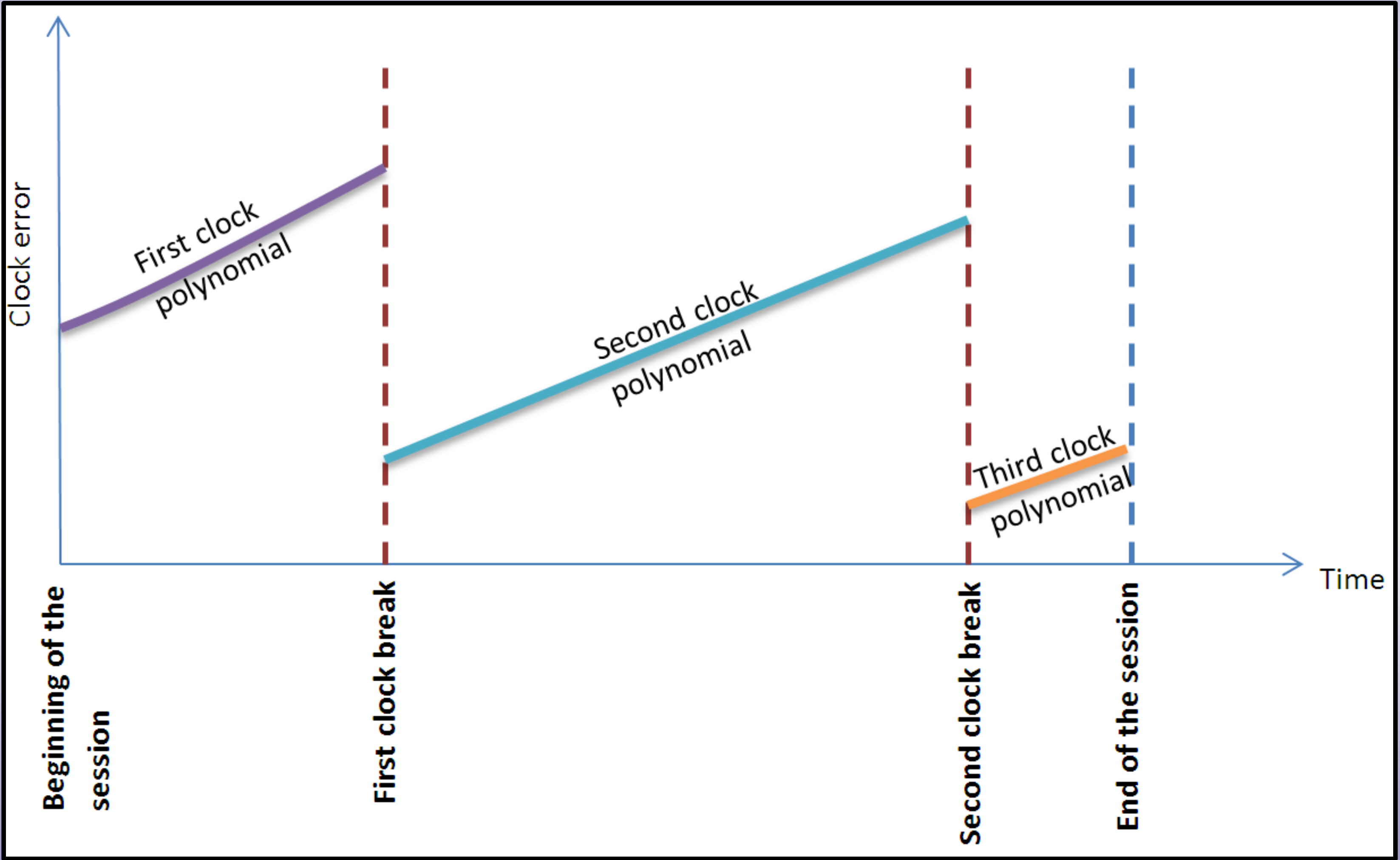
TRF datum impose with NNT, NNR, and NNS condition equations

- $$C_i = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -z'_i & y'_i \\ z'_i & 0 & -x'_i \\ -y'_i & x'_i & 0 \\ x'_i & y'_i & z'_i \end{bmatrix} \quad ; \quad \begin{bmatrix} x_{est\_i} \\ y_{est\_i} \\ z_{est\_i} \end{bmatrix} = \begin{bmatrix} x_{apr\_i} \\ y_{apr\_i} \\ z_{apr\_i} \end{bmatrix} + {C_i}^T \begin{bmatrix} T_X \\ T_Y \\ T_Z \\ \alpha \\ \beta \\ \gamma \\ \mu \end{bmatrix}$$
- $C = [C_1 \;\; C_2 \;\; \ldots \;\; C_n]$ n : number of antennas that Helmert Transformation are applied.
- $x'_i = norm \ast x_{0i}$
- $$norm = \frac{1}{\sqrt{\sum({x_{0i}}^2 + {y_{0i}}^2 + {z_{0i}}^2)}}$$

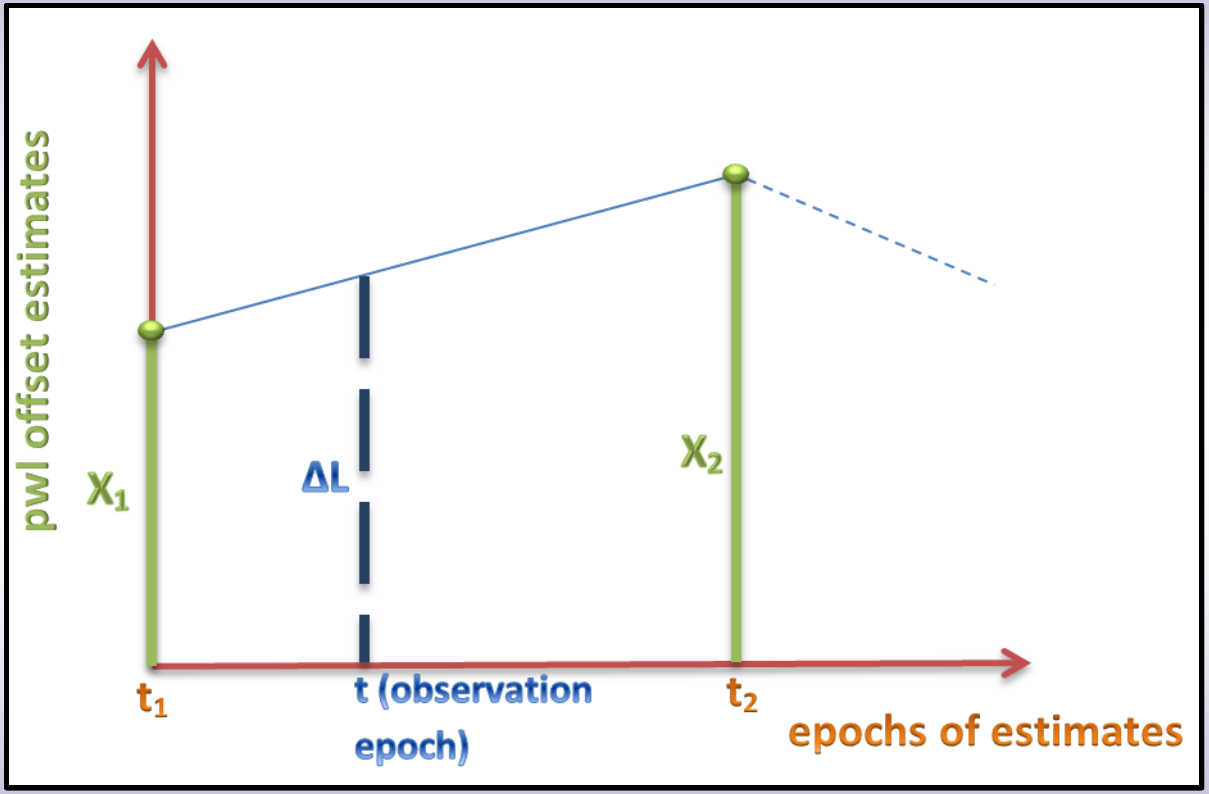
TRF datum impose for a regular solution

- One option may be to fix at least 3 antenna TRF coordinates to their a priori values, when CRF is fixed, EOP is estimated.
- Second option may be to fix 5 EOPs and CRF (fix rotation of TRF w.r.t. a priori CRF and EOP) and fix only one antenna TRF coordinates to it's a priori values.
- Third option may be not to estimate any antenna coordinates and fixing them to their a priori TRF catalogue values.
- Fourth option may be estimating EOPs and constraining the coordinates of antennas in such a way that the estimated TRF will have no-net-translation (NNT) and no-net-rotation (NNR) w.r.t. a priori TRF.
- Fifth option may be fixing EOP and CRF (rotations of the estimated TRF will be fixed to a priori EOP and a priori CRF) and applying only translation constraints on the station coordinates in such a way that the estimated TRF will have no translations w.r.t. a priori TRF.
- In the future imposing the TRF datum on the estimated antenna coordinates with absolute constraints (pseudo observations in design matrix) to vie_lsm would be nice.

Fixing clock breaks (treated in the first ls solution)



piece wise linear (pwl) offset parameters to be estimated with LS



$$\Delta L = X_1 + \frac{t_2 - t}{t_2 - t_1}(X_2 - X_1)$$

- X_1 and X_2 are pwl offsets estimated at integer UTC hours (t_1 and t_2).
- ΔL is the observation carried out at t.

clocks' synchronization and frequency errors modeling with piece wise linear (pwl) offsets

$$\Delta L_{poly}^{clk_i}(t) = \beta_0^{clk_i} + \beta_1^{clk_i}(t - t_0) + \beta_2^{clk_i}(t - t_0)^2$$

$$\frac{\partial \Delta L_{poly}^{clk_i}(t)}{\partial \beta_0} = 1,$$

$$\frac{\partial \Delta L_{poly}^{clk_i}(t)}{\partial \beta_1} = t - t_0,$$

$$\frac{\partial \Delta L_{poly}^{clk_i}(t)}{\partial \beta_2} = (t - t_0)^2$$

Partial derivatives of clock polynomial w.r.t. its coefficients

$$\Delta L_{pwl}^{clk_i}(t) = x_1 + \frac{t - t_1}{t_2 - t_1}(x_2 - x_1)$$

$$\frac{\partial \Delta L_{pwl}^{clk_i}(t)}{\partial x_1} = 1 - \frac{t - t_1}{t_2 - t_1}$$

$$\frac{\partial \Delta L_{pwl}^{clk_i}(t)}{\partial x_2} = \frac{t - t_1}{t_2 - t_1}$$

Partial derivatives of pwl offset function w.r.t. its offsets clocks' synchronization and frequency errors modeling with piece wise linear (pwl) offsets

$$\Delta L^{clk_i}(t) = \Delta L^{clk_i}_{poly}(t) + \Delta L^{clk_i}_{pwlof}(t)$$

$$\Delta L^{clk_{i,k}}(t) = \Delta L^{clk_i}(t) - \Delta L^{clk_k}(t)$$

The design matrix of pwlos and polynomial for a scan including 3 observations, 3 antennas, one estimation interval, result in 2 offsets for each station:

$$\begin{bmatrix} \frac{\partial \Delta L^{clk_1}_{pwl}(t1)}{\partial x_1} & \frac{\partial \Delta L^{clk_1}_{pwl}(t1)}{\partial x_2} & \frac{-\partial \Delta L^{clk_2}_{pwl}(t1)}{\partial x_1} & \frac{-\partial \Delta L^{clk_2}_{pwl}(t1)}{\partial x_2} & 0 & 0 \\ 0 & 0 & \frac{\partial \Delta L^{clk_2}_{pwl}(t2)}{\partial x_1} & \frac{\partial \Delta L^{clk_2}_{pwl}(t2)}{\partial x_2} & \frac{-\partial \Delta L^{clk_3}_{pwl}(t2)}{\partial x_1} & \frac{-\partial \Delta L^{clk_3}_{pwl}(t2)}{\partial x_2} \\ \frac{\partial \Delta L^{clk_1}_{pwl}(t3)}{\partial x_1} & \frac{\partial \Delta L^{clk_1}_{pwl}(t3)}{\partial x_2} & 0 & 0 & \frac{-\partial \Delta L^{clk_3}_{pwl}(t3)}{\partial x_1} & \frac{-\partial \Delta L^{clk_3}_{pwl}(t3)}{\partial x_2} \end{bmatrix}$$

$$\begin{bmatrix} \frac{\partial \Delta L^1(t1)}{\partial \beta_0} & \frac{-\partial \Delta L^2(t1)}{\partial \beta_0} & 0 & \frac{\partial \Delta L^1(t1)}{\partial \beta_1} & \frac{-\partial \Delta L^2(t1)}{\partial \beta_1} & 0 & \frac{\partial \Delta L^1(t1)}{\partial \beta_2} & \frac{-\partial \Delta L^2(t1)}{\partial \beta_2} & 0 \\ 0 & \frac{\partial \Delta L^2(t2)}{\partial \beta_0} & \frac{-\partial \Delta L^3(t2)}{\partial \beta_0} & 0 & \frac{\partial \Delta L^2(t2)}{\partial \beta_1} & \frac{-\partial \Delta L^3(t2)}{\partial \beta_1} & 0 & \frac{\partial \Delta L^2(t2)}{\partial \beta_2} & \frac{-\partial \Delta L^3(t2)}{\partial \beta_2} \\ \frac{\partial \Delta L^1(t3)}{\partial \beta_0} & 0 & \frac{-\partial \Delta L^3(t3)}{\partial \beta_0} & \frac{\partial \Delta L^1(t3)}{\partial \beta_1} & 0 & \frac{-\partial \Delta L^3(t3)}{\partial \beta_1} & \frac{\partial \Delta L^1(t3)}{\partial \beta_2} & 0 & \frac{-\partial \Delta L^3(t3)}{\partial \beta_2} \end{bmatrix}$$

ZWDs modeling by piece wise linear (pwl) offsets

$$\Delta L_w^s(t) = m_w(t)\, x_1 + m_w(t)\, \frac{t - t_1}{t_2 - t_1}\, (x_2 - x_1)$$

$$\frac{\partial \Delta L_w^s(t)}{\partial x_1} = m_w(t) - m_w(t)\, \frac{t - t_1}{t_2 - t_1}$$

$$\frac{\partial \Delta L_w^s(t)}{\partial x_2} = m_w(t)\, \frac{t - t_1}{t_2 - t_1}$$

Partial derivatives of pwl offset function w.r.t. its offsets are multiplied by $m_w(t, \varepsilon)$ (wet MF of the observation). $m_w(t, \varepsilon)$ is the partial derivative of the troposphere delay function (Davis et al., 1993) w.r.t. unknown ZWD.

troposphere total gradients modeling by piece wise linear (pwl) offsets and estimating with LS

$$\frac{\partial \Delta L^s_{gr_{north}}(t)}{\partial x_1} = m_w(t)\ \cot\varepsilon\ \cos(\alpha)\ [1 - \frac{t - t_1}{t_2 - t_1}]$$

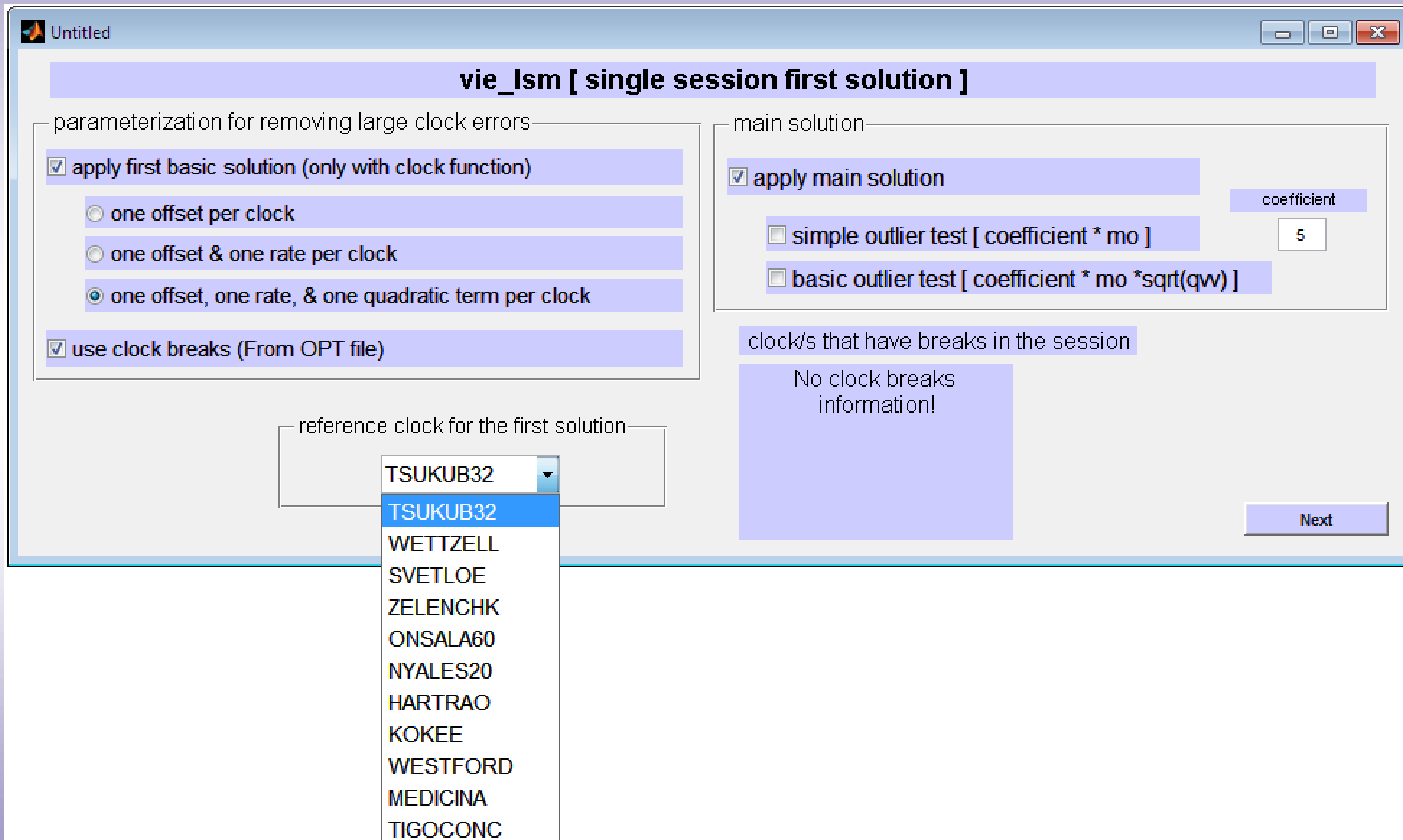
$$\frac{\partial \Delta L^s_{gr_{north}}(t)}{\partial x_2} = m_w(t)\ \cot\varepsilon\ \cos(\alpha)\ [\frac{t - t_1}{t_2 - t_1}]$$

$$\frac{\partial \Delta L^s_{gr_{east}}(t)}{\partial x_1} = m_w(t)\ \cot\varepsilon\ \sin(\alpha)\ [1 - \frac{t - t_1}{t_2 - t_1}]$$

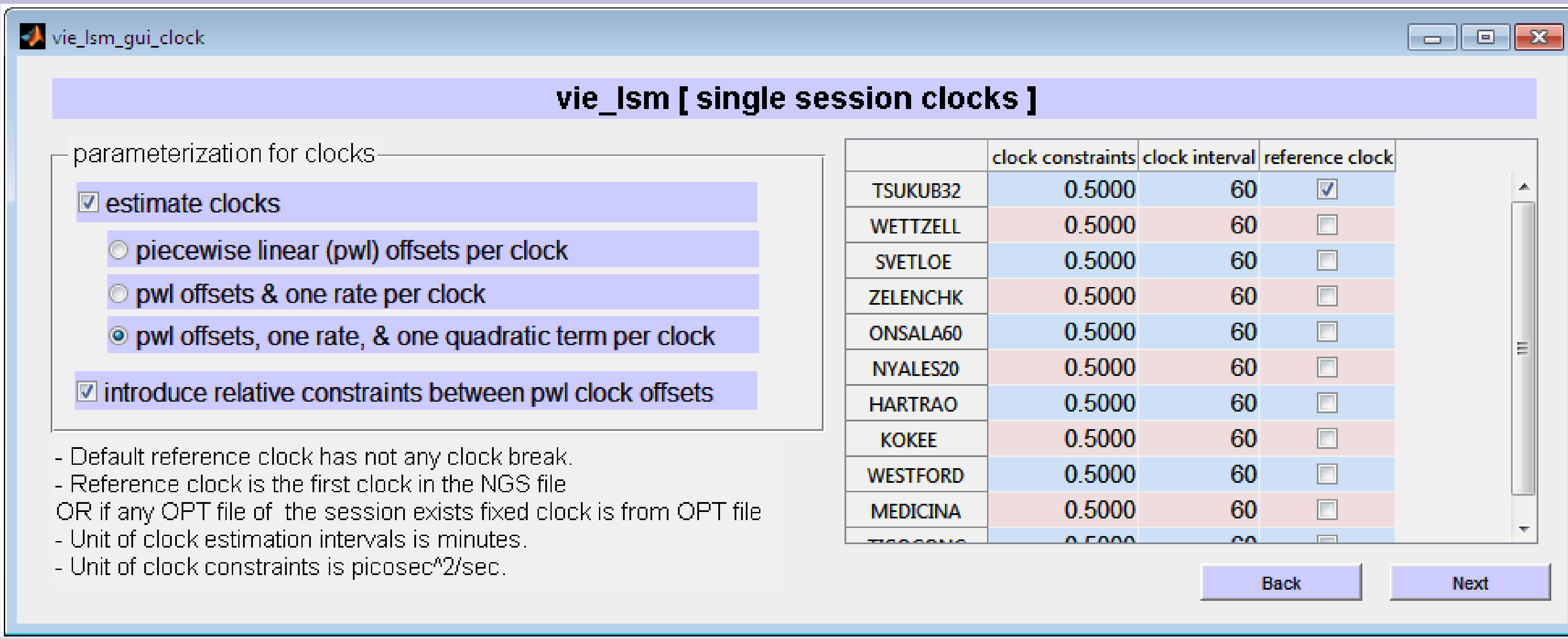
$$\frac{\partial \Delta L^s_{gr_{east}}(t)}{\partial x_2} = m_w(t)\ \cot\varepsilon\ \sin(\alpha)\ [\frac{t - t_1}{t_2 - t_1}]$$

Partial derivatives of pwl offset function w.r.t. its offsets are multiplied by the partial derivatives of the troposphere delay function (Davis et al., 1993) w.r.t. north and east troposphere gradients (G_N and G_E).

GUIs


Untitled
vie_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
TSUKUB32
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(qvv)]
clock/s that have breaks in the session
No clock breaks information!
Next

GUIs


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
TSUKUB32 0.5000 60
WETTZELL 0.5000 60
SVETLOE 0.5000 60
ZELENCHK 0.5000 60
ONSALA60 0.5000 60
NYALES20 0.5000 60
HARTRAO 0.5000 60
KOKEE 0.5000 60
WESTFORD 0.5000 60
MEDICINA 0.5000 60
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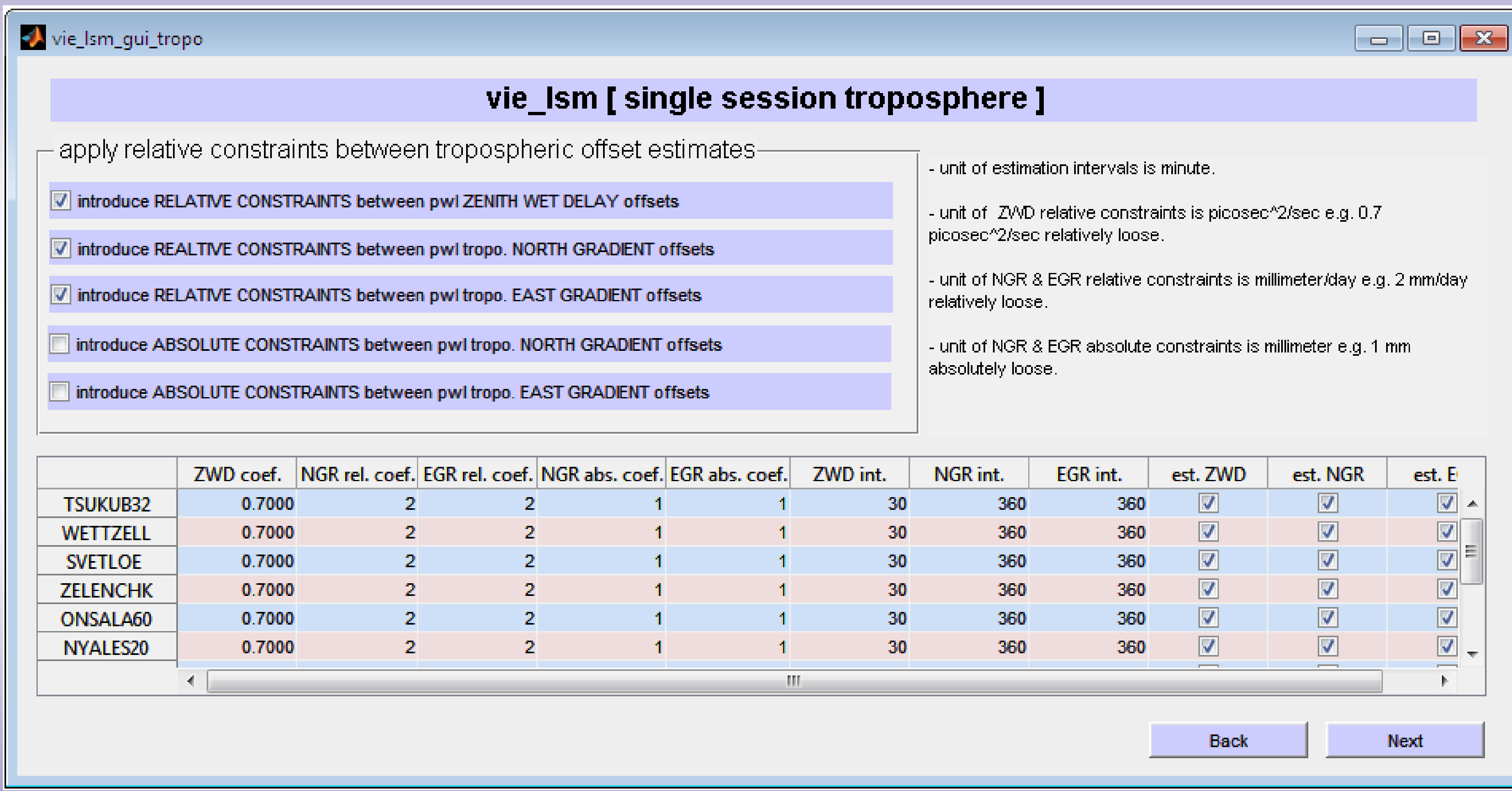
GUIs


vie_lsm_gui_tropo
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 picosec^2/sec e.g. 0.7 picosec^2/sec relatively loose.
- unit of NGR & EGR relative constraints is millimeter/day e.g. 2 mm/day relatively loose.
- unit of NGR & EGR absolute constraints is millimeter e.g. 1 mm 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. E
TSUKUB32 | 0.7000 | 2 | 2 | 1 | 1 | 30 | 360 | 360
WETTZELL | 0.7000 | 2 | 2 | 1 | 1 | 30 | 360 | 360
SVETLOE | 0.7000 | 2 | 2 | 1 | 1 | 30 | 360 | 360
ZELENCHK | 0.7000 | 2 | 2 | 1 | 1 | 30 | 360 | 360
ONSALA60 | 0.7000 | 2 | 2 | 1 | 1 | 30 | 360 | 360
NYALES20 | 0.7000 | 2 | 2 | 1 | 1 | 30 | 360 | 360
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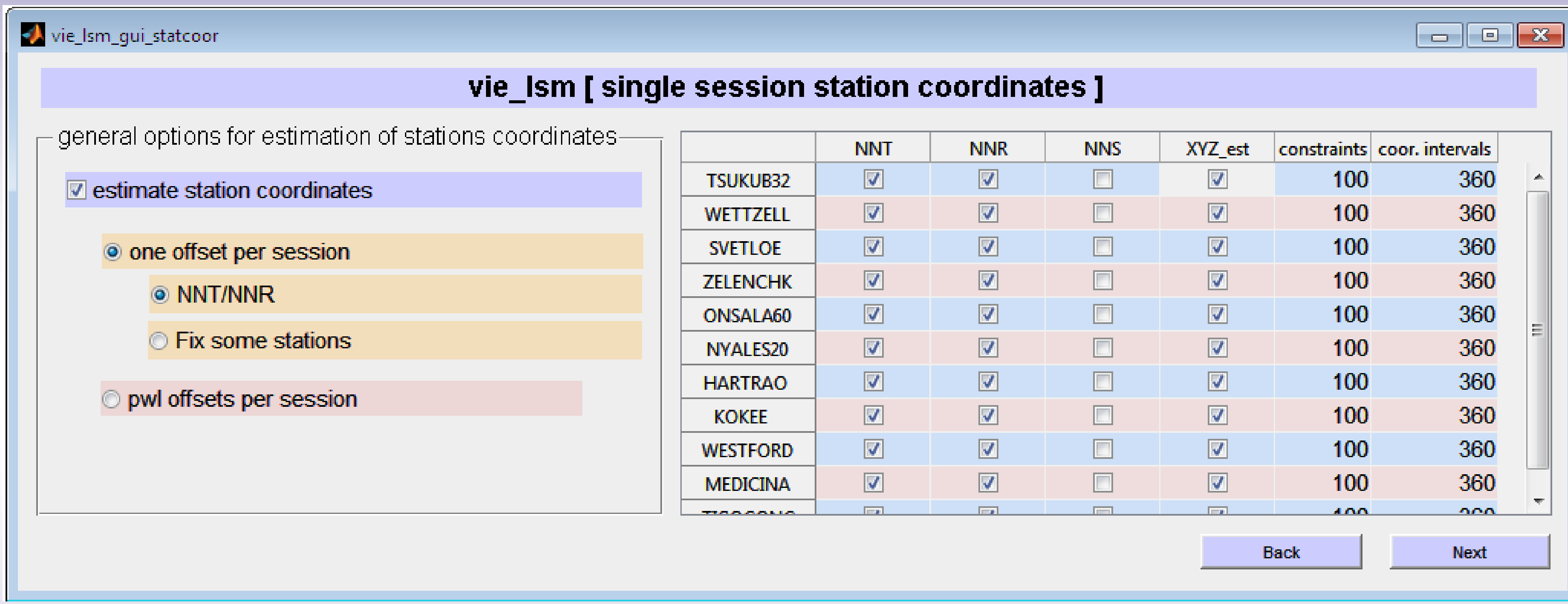
GUIs


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
coor. intervals
TSUKUB32 100 360
WETTZELL 100 360
SVETLOE 100 360
ZELENCHK 100 360
ONSALA60 100 360
NYALES20 100 360
HARTRAO 100 360
KOKEE 100 360
WESTFORD 100 360
MEDICINA 100 360
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GUIs

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)	☑	40	☐	1.0000e-04
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.
- 3 mas/day and 3 ms/day are loose constraints.
- 0.001 mas/day and 0.001 ms/day are tight constraints.

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GUIs

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/day.
- unit of coordinate estimation intervals in minutes.
- Please, fix at least one source which has more than 1 observation
if you select estimate sources

	source name	total observations	est. coor.	constraints	coor. interval
1	0235+164	424	☐	1.0000e-04	1440
2	1334-127	182	☐	1.0000e-04	1440
3	0133+476	559	☐	1.0000e-04	1440
4	0642+449	717	☐	1.0000e-04	1440
5	1357+769	873	☑	1.0000e-04	1440
6	0955+476	633	☐	1.0000e-04	1440
7	4C39.25	558	☐	1.0000e-04	1440
8	0552+398	583	☐	1.0000e-04	1440
9	0528+134	158	☐	1.0000e-04	1440
10	1611+343	489	☐	1.0000e-04	1440
11	3C446	174	☐	1.0000e-04	1440
12	2136+141	256	☐	1.0000e-04	1440
13	2209+236	299	☐	1.0000e-04	1440
14	0119+115	186	☐	1.0000e-04	1440
15	0059+581	211	☐	1.0000e-04	1440
16	1958-179	87	☐	1.0000e-04	1440
17	0201+113	22	☐	1.0000e-04	1440
18	1519-273	57	☐	1.0000e-04	1440
19	2255-282	7	☐	1.0000e-04	1440

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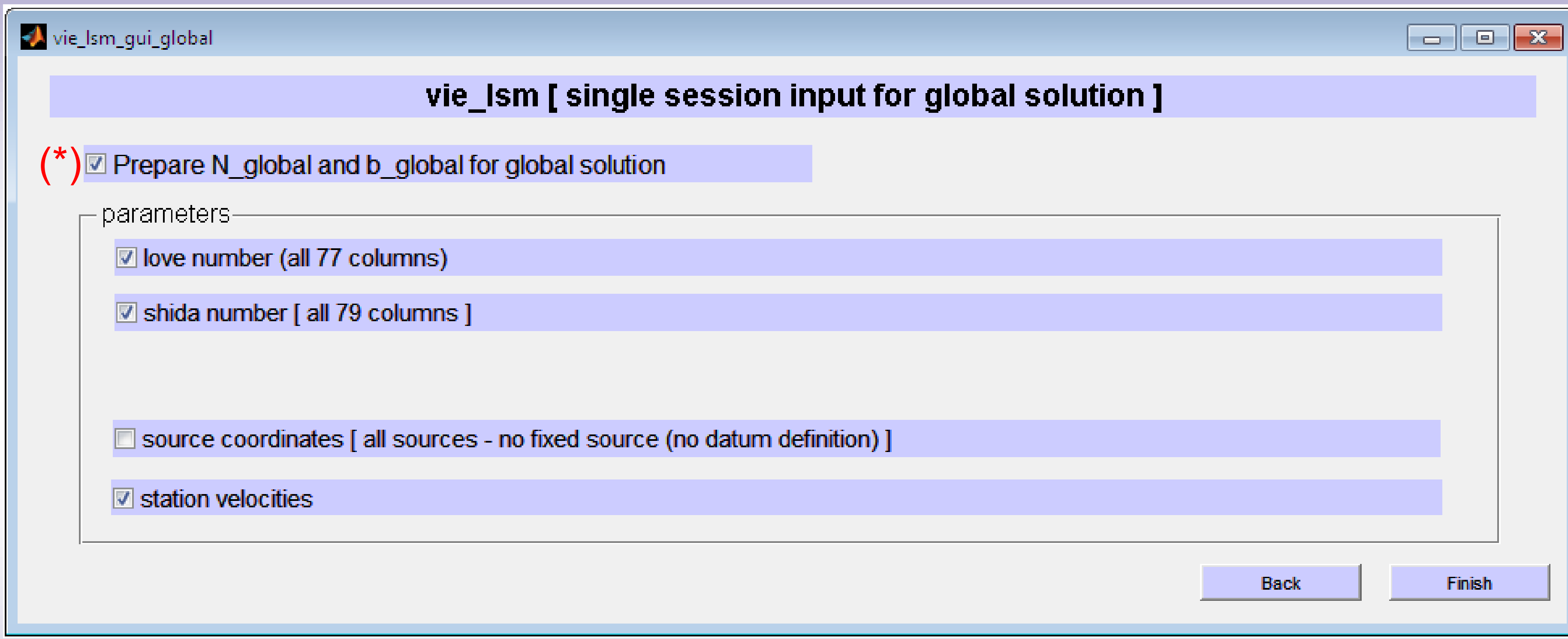
GUIs



! The datum free N and b are created when (*) is selected. In case, in this GUI only (*) **is selected but not the other options** then by default datum free N and b will be formed including the parameters of clocks, ZWDs, troposphere gradients, antenna coordinates, and EOPs. The N and b for global solution saved in ../DATA/LEVEL2/'USER_DIR/*.mat.

vie_lsm outputs

- 'VieVS/DATA/LEVEL3/USER_DIR/opt_',fname,'.mat'
  - **opt_ :** Session process general options are stored. E.g. epoch of the first and last scan of the session in mjd (.first_scan, and .last_scan), fixed clock number and name (.ref_first_clk, and .fixed_clock), fixed station/s to its/their a priori TRF coordinates (.fixed_station), total observations carried out within the session (.total_obs), the vector of total estimates defining the model boundaries (.totalest = [0 175 189 580 …]), a priori and a posteriori std. dev. of unit weight (.s0 and .m0) , …
  - **opt_.stat(8) :** 8^{th} antenna related parameterizations covering all and last options that are chosen by the user via the GUIs. E.g. 8^{th} antennas pwl ZWD offsets were estimated (.zwd_inc = 1 “0”) at every UTC hours (.int_zwd = 60), and constrained relatively loose (.coef_zwd = 0.7 “picosec^2/sec” is loose) .

Note: variable names, their units, default values and descriptions can be found in: ‘VieVS/DOC/VieVS_variables.pdf’

vie_lsm outputs

- 'VieVS/DATA/LEVEL3/USER_DIR/opt_',fname,'.mat'
  - **opt_.source(42) :** 42nd source related parameterizations covering all and last options that are chosen by the user via the vie_lsm GUIs. E.g. total number of observations carried out to the source within the session (.total_obs), name of the source (.name), do not estimate pwlo CRF coordinates of this source (.rade_inc = 0 “1”), CRF catalogue coordinates (.de and .ra).
  - **opt_.xpol :** Polar motion coordinate along the Greenwich meridian estimation options. E.g. if the model was included in the analysis (.model = 1 “0”), pwlo estimation interval (.int = 1440), if relative constraints were used (.constrain = 1 “0”), if the weight of constraints were loose or tight (.coef = 30 “in units of mas/day means loosely constrained”), …

Note: variable names, their units, default values and descriptions can be found in: ‘VieVS/DOC/VieVS_variables.pdf’

vie_lsm outputs

- 'VieVS/DATA/LEVEL3/USER_DIR/x_',fname,'.mat'
  - **x_. :** All the estimated parameters (e.g.: .xpol.val), their estimation epochs (e.g.: .xpol.mjd) and formal errors (e.g.: xpol.mx) are stored in this structure array. In addition, the column (row) number of the estimated parameter in N and b (e.g. .xpol.col) are included in.
- 'VieVS/DATA/LEVEL3/USER_DIR/atpa_',fname,'.mat'
  - **atpa_.mat :** Normal equation coefficient matrix (N) (TRF datum imposed). Exactly, this matrix is inverted in vie_lsm to estimate parameters.
  - atpl_.vec : Normal equation constants vector (b). Exactly, this vector is used in vie_lsm to estimate parameters.

LEVEL2 (directory where vie_lsm outputs are stored for vie_glob input)

- 'VIEVS/DATA/LEVEL2/USER_DIR/fname_an_glob.mat' → glob1.an (antenna related information as input for global solution).
- 'VIEVS/DATA/LEVEL2/USER_DIR/fname_par_glob.mat' → glob2.x : column and row numbers of N and b corresponding to the parameters that will be estimated by global solution, glob2.opt : number of total constrain equations on the parameters ".nconstr", and weighted square sum of the o-c vector ".lTPl".
- 'VIEVS/DATA/LEVEL2/USER_DIR/fname_Nb_glob.mat' → glob3 : Datum free N (.N) and b (.b).

Note: variable names, their units, default values and descriptions can be found in: 'VieVS/DOC/VieVS_variables.pdf'

Conclusion

- vie_lsm is a module of VieVS, estimates geodetic parameters with least squares adjustment from VLBI observations.
- Being based on the partial derivatives of the state-of-the art models which are consistent with IERS 2003 conventions vie_lsm estimates are reliable and accurate as much as other scientific software used for VLBI parameter estimation.
- Several comparisons were carried out on the estimates of VieVS with other space geodetic techniques solutions and results show good agreements.
- In the functional model by means of using piece-wise-linear offset functions where rates are represented by offsets vie_lsm produces directly offset estimates at unique epochs e.g. UTC integer hours.
- Flexible options of vie_lsm offers analyst too many parameterization alternatives.
- The codes were written in vie_lsm as clear as possible with lots of comments where the user can easily introduce modifications according to her needs.
- vie_lsm should be improved in terms of solving workspace problem for the future sessions of which number of observations exceeds ~30.000.

Thank you so much for your attention!