

9th VieVS User Workshop, Vienna, September 11 – 12, 2018

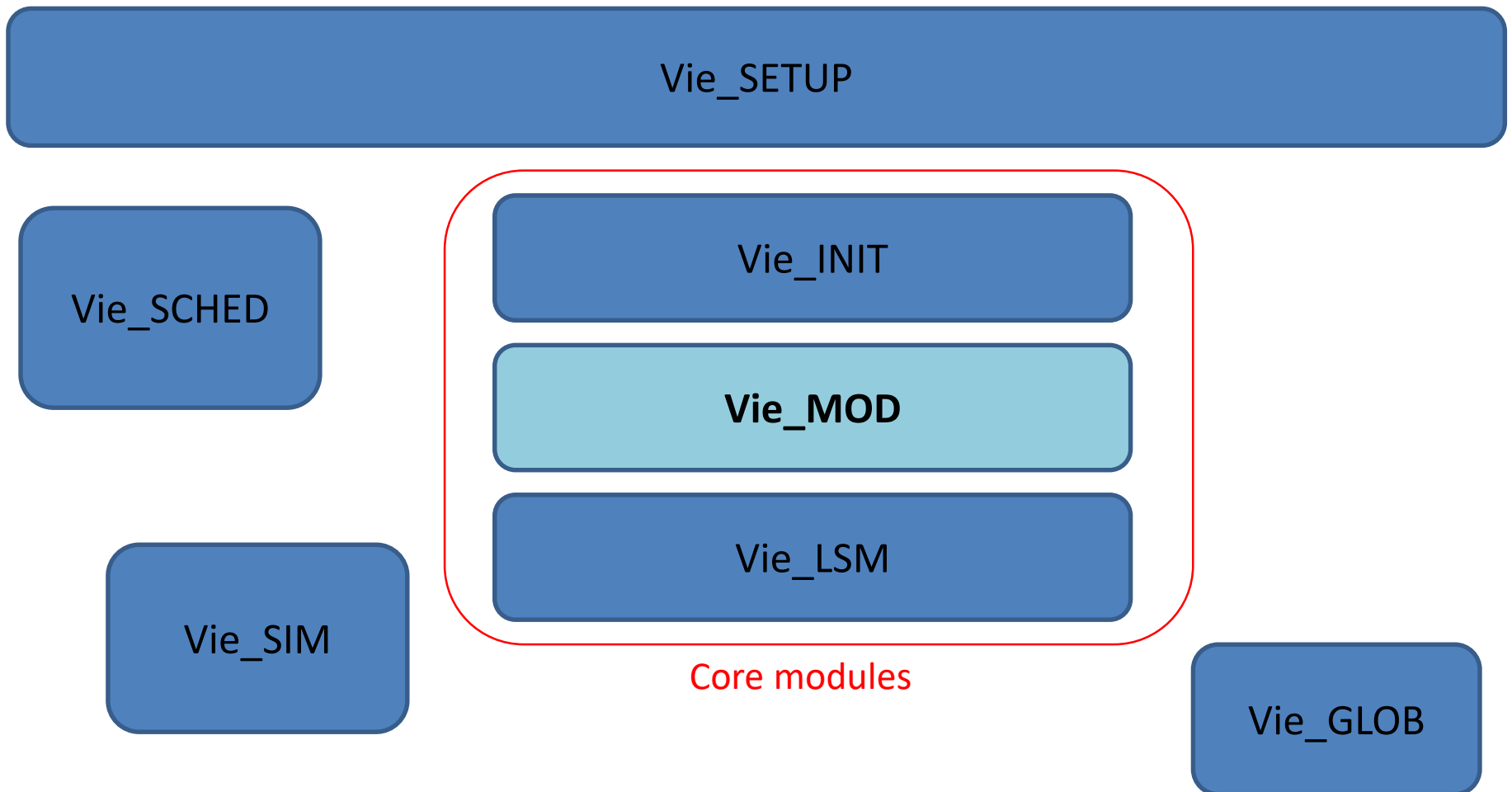
VIE_MOD 3.1

Andreas Hellerschmied



- **MOD**elling of....
 - Computed delay times τ_{comp}
 - Partial derivatives $\frac{\partial \tau}{\partial VAR}$

VieVS Modules

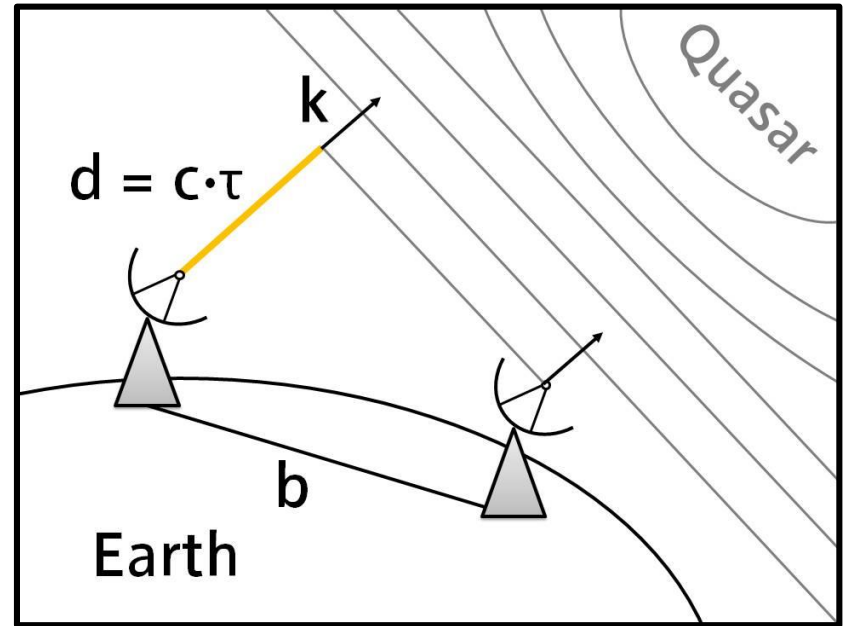


Vie_MOD...calculates the **theoretical time delay** and builds up the **partial derivatives**

Basics (1)

computed delay τ

$$\tau = -\frac{\vec{b} \cdot \vec{k}}{c}$$

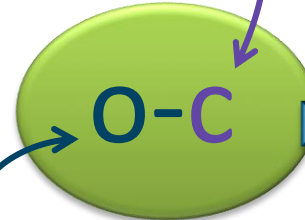


computed delay τ_{comp}

- Vie_MOD

observed delay τ_{obs}

- From **observation file** (NGS, VSO, vgosDB), corrected for ionosphere



Adjustment
(LSM)

Basics (2)

Models in Vie_MOD

- + Tropospheric delay
- + Solid Earth tides
- + Ocean loading
- + Atmospheric loading
- + Hydrologic loading
- + Thermal antenna deformation
- + EOP

Partial derivatives

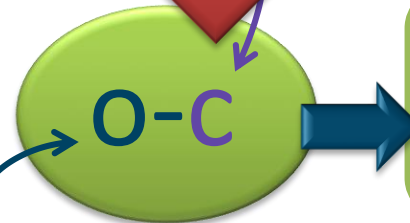
$$\frac{\partial \tau}{dVAR}$$

computed delay τ_{comp}

- Vie_MOD

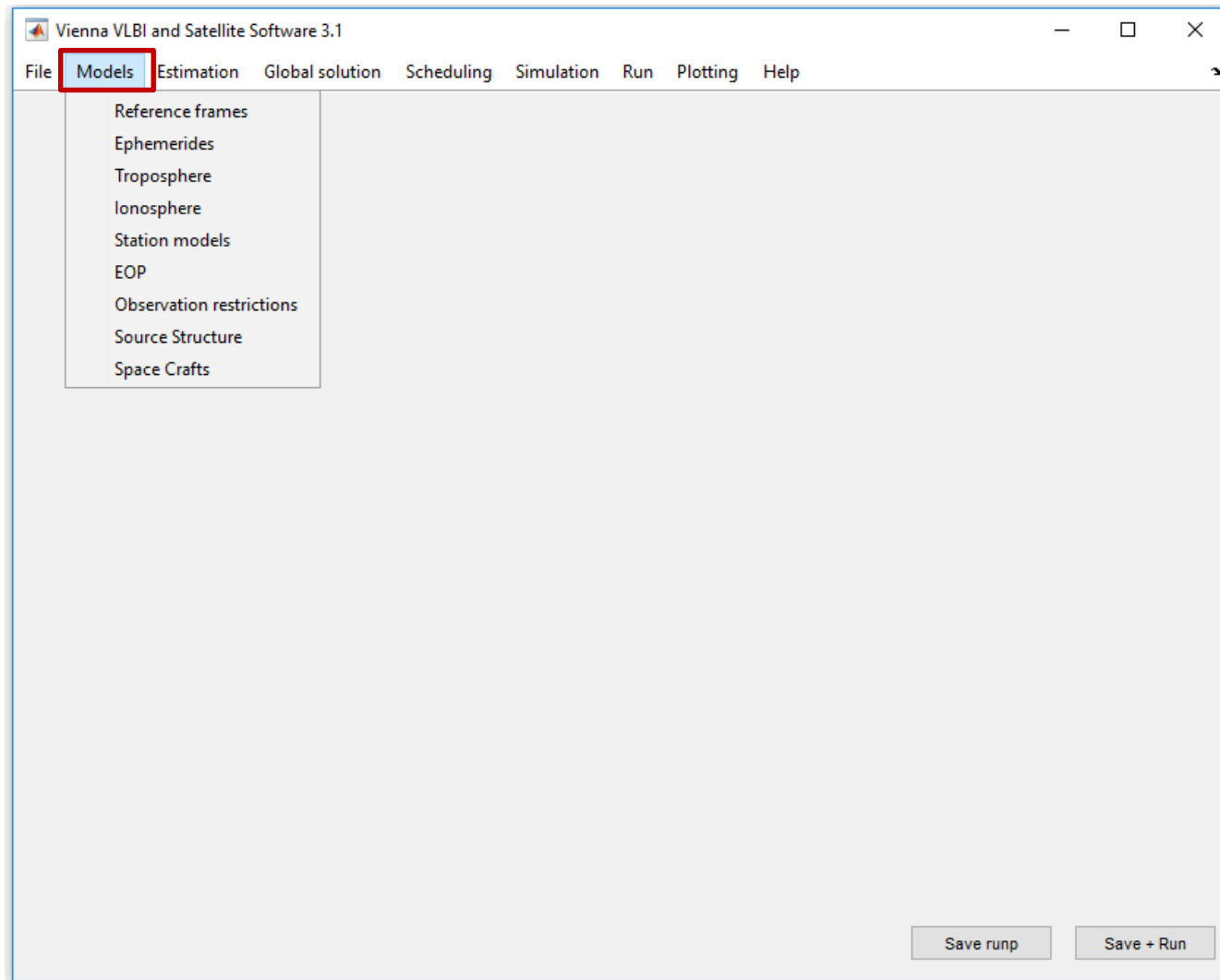
observed delay τ_{obs}

- From **observation file** (NGS, VSO, vgosDB), corrected for ionosphere

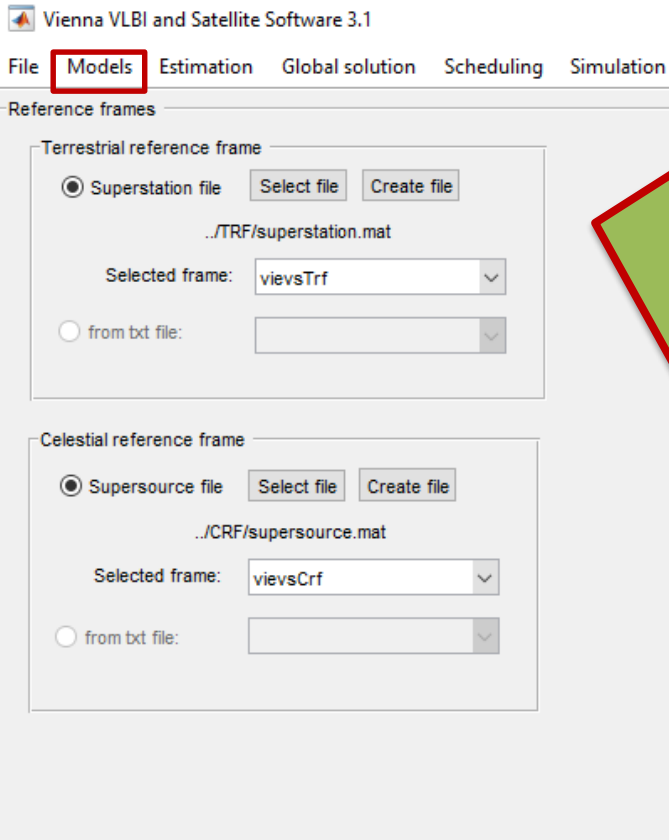


Adjustment
(LSM)

Usage of VIE_MOD



Reference frames - TRF



Terrestrial Reference Frame:

• Superstation files

Exercise!

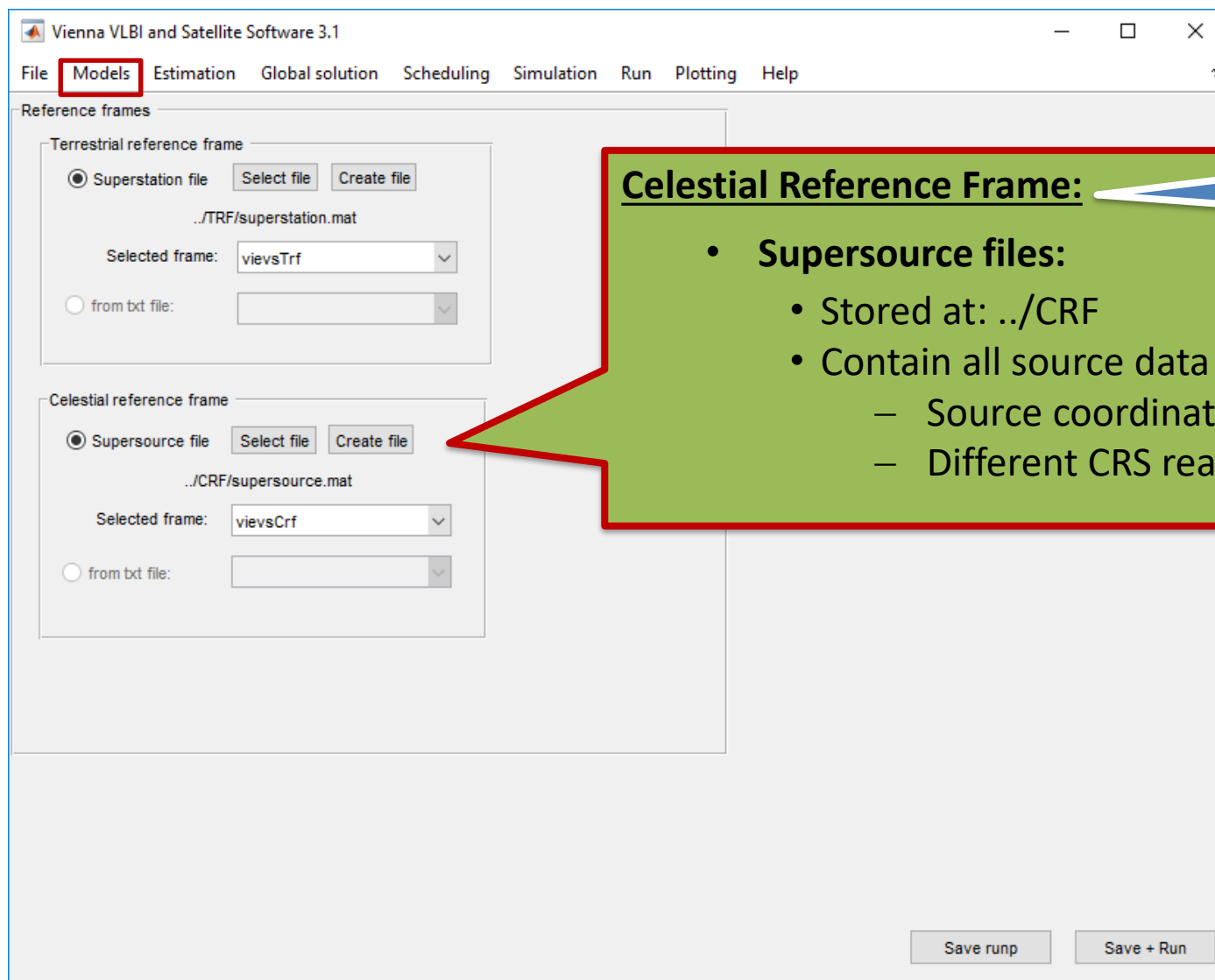
- Stored at: ../TRF
- Contain all the station data
 - Station coordinates (TRS)
 - Station velocities
 - Reference epoch
 - Different TRF included
 - Station corrections

• From txt file:

- Stored at ../TRF/* .txt
- Specified format
 - 8 char. stat. name
 - Column-mode

% station	x [m]	y [m]	z [m]	vx [m/y]	vy [m/y]	vz [m/y]	epoch	start	end
ALGOPARK	918034.6948	-4346132.2778	4561971.1788	-0.0157	-0.0042	0.0042	51544	0	99999
BR-VLBA	-2112065.0172	-3705356.5129	4726813.7718	-0.0143	0.0003	-0.0076	51544	0	99999
BADARY	-838200.7126	3865751.5854	4987670.9332	-0.0272	-0.0020	-0.0019	51544	0	99999
CRIMEA	3785231.0045	2551207.4646	4439796.4156	-0.0203	0.0159	0.0102	51544	0	99999
CTVASTJ	2612545.6380	-3426878.7527	4686756.1070	-0.0162	-0.0042	0.0111	51544	0	99999
DSS45	-4460935.5060	2682765.7012	-3674381.0520	-0.0357	0.0010	0.0457	51544	0	99999
DSS65	4849336.6707	-360488.7368	4114748.8877	-0.0068	0.0189	0.0155	51544	0	50553
DSS65	4849336.6685	-360488.7334	4114748.8760	-0.0068	0.0189	0.0155	51544	50553	99999
DSS15	-2353538.8966	-4641649.4516	3676669.9816	-0.0183	0.0062	-0.0027	51544	0	48800
DSS15	-2353538.8964	-4641649.4590	3676669.9703	-0.0183	0.0062	-0.0027	51544	48800	99999

Reference frames - CRF



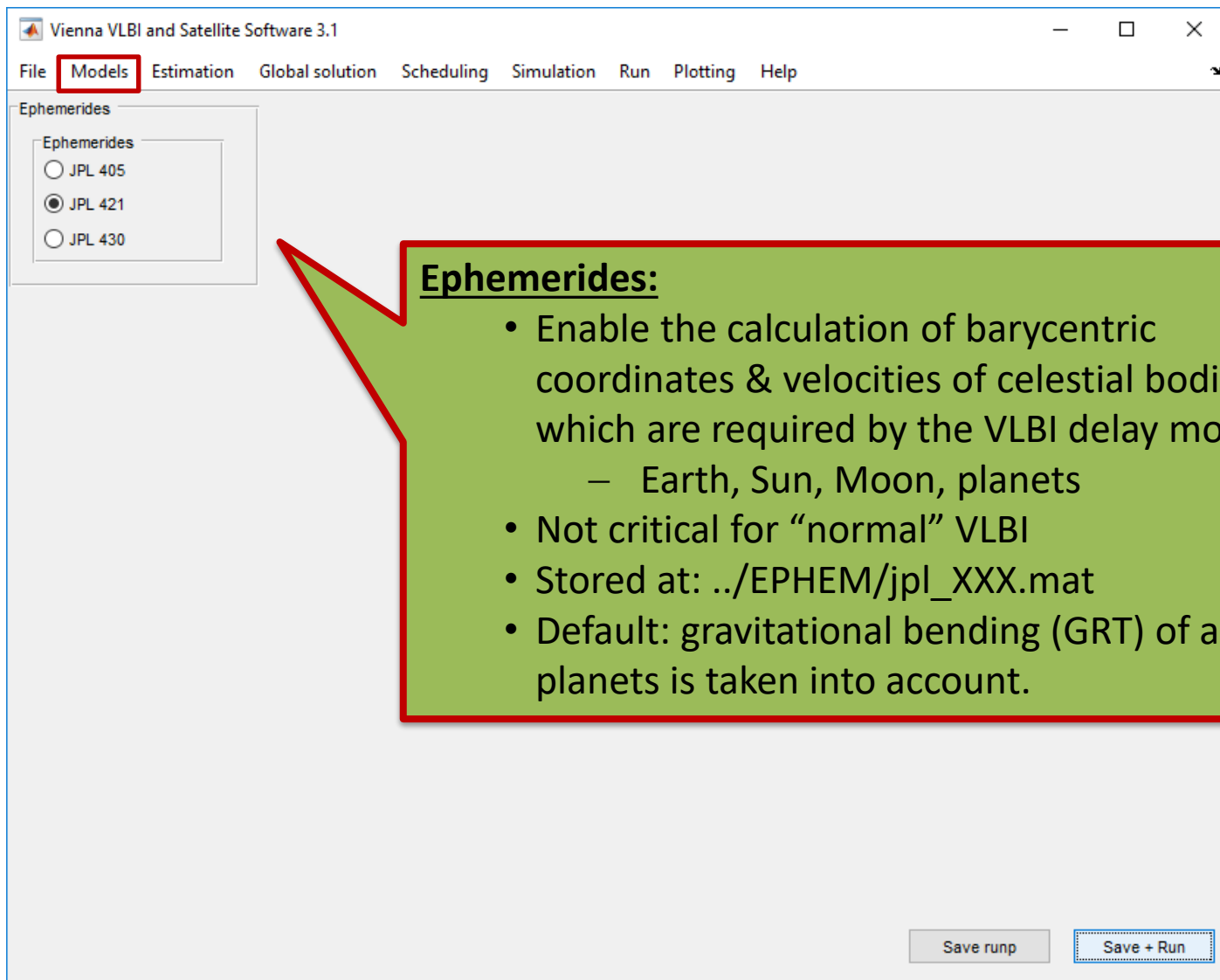
Celestial Reference Frame:

- **Supersource files:**

- Stored at: ../CRF
- Contain all source data
 - Source coordinates(Ra, Dec)
 - Different CRS realzations

Exercise!

Ephemerides



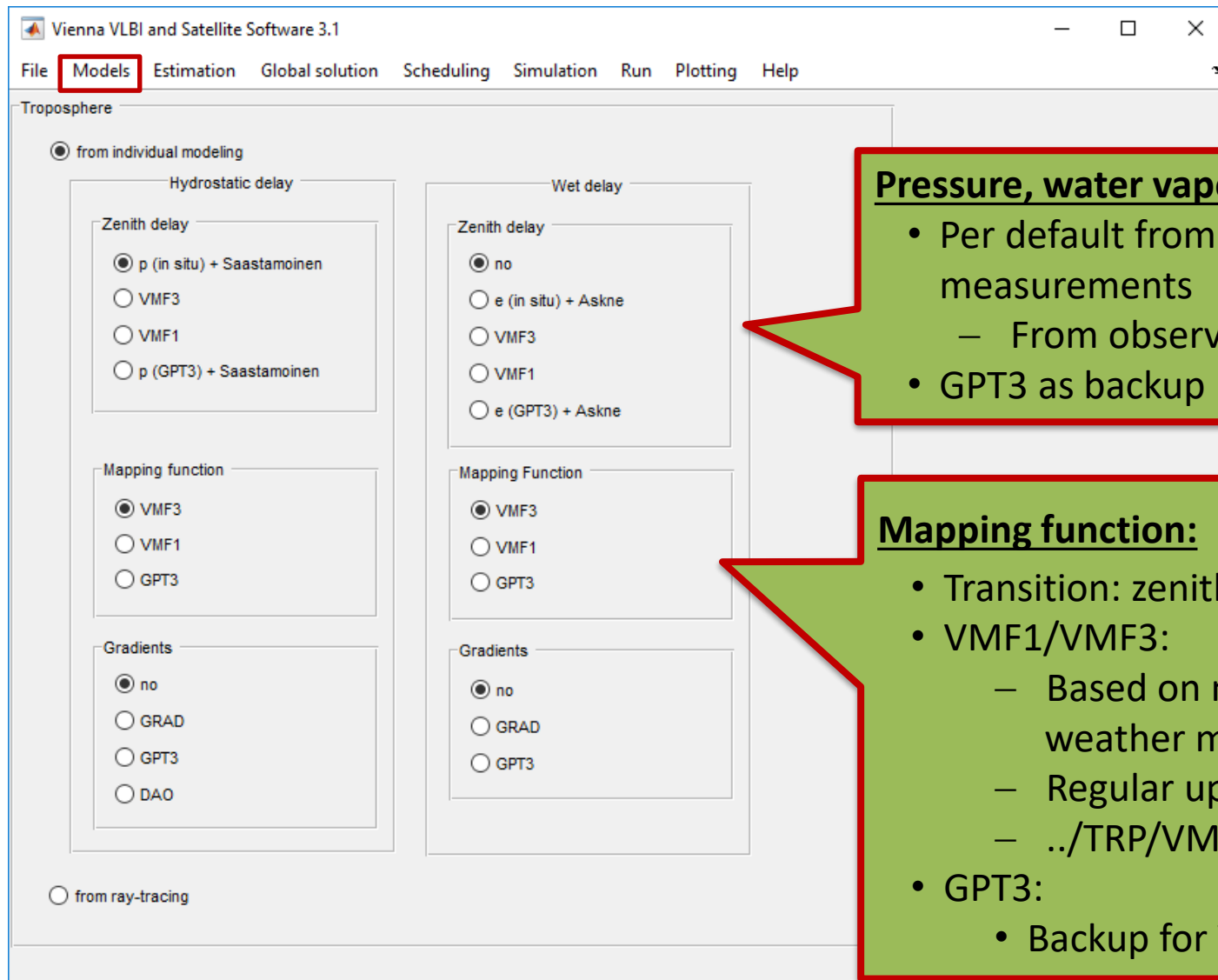
The screenshot shows the 'Vienna VLBI and Satellite Software 3.1' application window. The 'Models' menu is highlighted in red. Below it, the 'Ephemerides' section is visible, containing three radio button options: 'JPL 405', 'JPL 421' (which is selected), and 'JPL 430'. A red callout box with a green background points to the 'Ephemerides' section and contains the following text:

Ephemerides:

- Enable the calculation of barycentric coordinates & velocities of celestial bodies, which are required by the VLBI delay model.
 - Earth, Sun, Moon, planets
- Not critical for “normal” VLBI
- Stored at: ../EPHEM/jpl_XXX.mat
- Default: gravitational bending (GRT) of all planets is taken into account.

At the bottom right of the window, there are two buttons: 'Save runp' and 'Save + Run'.

Troposphere (1)



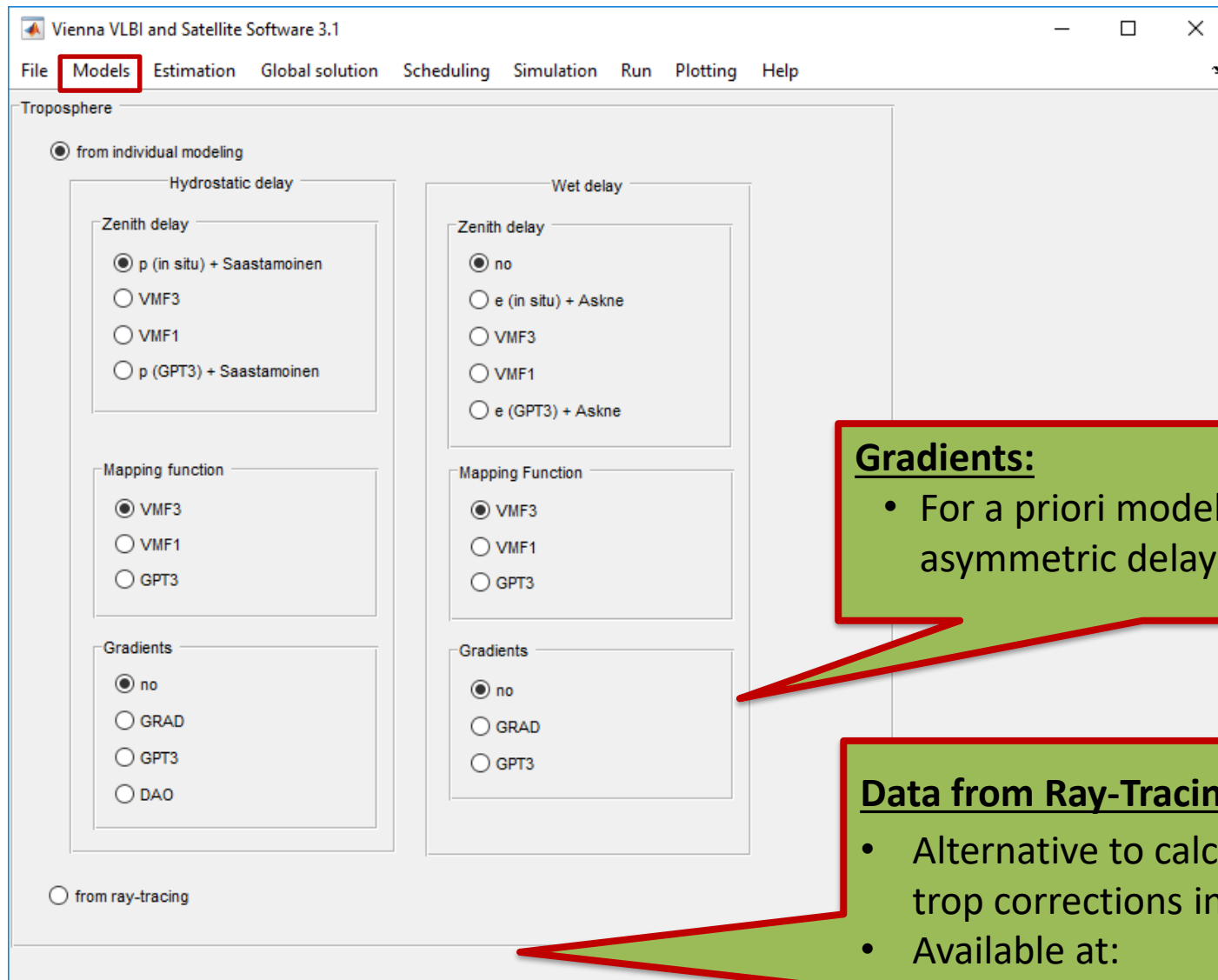
Pressure, water vapor pressure:

- Per default from in situ measurements
 - From observation files
- GPT3 as backup

Mapping function:

- Transition: zenith- to slant-delays
- VMF1/VMF3:
 - Based on numerical weather models
 - Regular updates!
 - `../TRP/VMx/yyyyy.vmfx_r`
- GPT3:
 - Backup for VMF1 and VMF3

Troposphere (2)



Gradients:

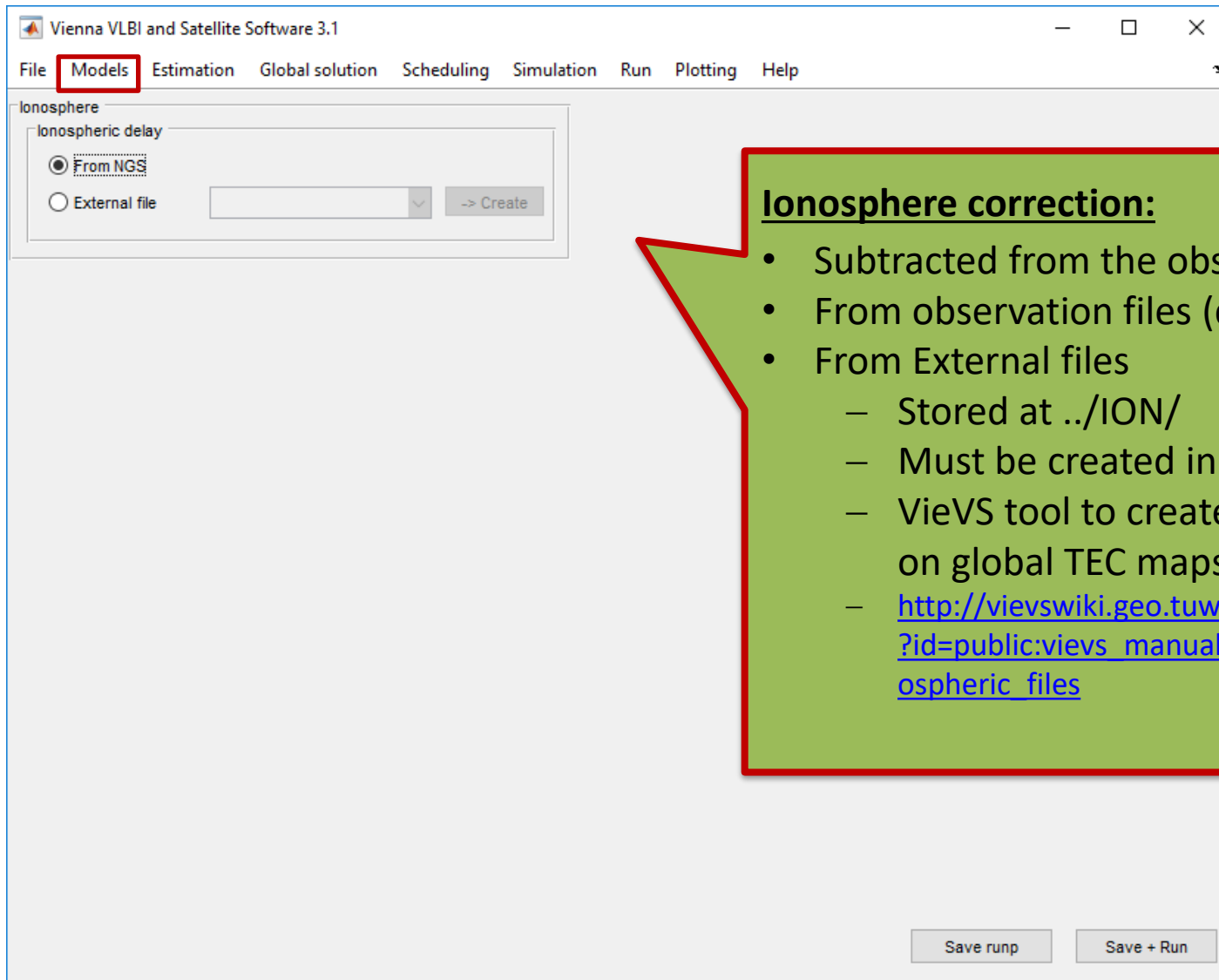
- For a priori modelling of azimuthally asymmetric delays

Data from Ray-Tracing

- Alternative to calculation of a priori trop corrections in VIE_MOD
- Available at:

<http://vmf.geo.tuwien.ac.at/>

Ionosphere



The screenshot shows the 'Vienna VLBI and Satellite Software 3.1' application window. The 'Models' menu is highlighted. The 'Ionosphere' section is active, showing the 'Ionospheric delay' options. The 'From NGS' radio button is selected, and the 'External file' option is also visible with a dropdown menu and a '-> Create' button. At the bottom of the window, there are 'Save runp' and 'Save + Run' buttons.

Ionosphere correction:

- Subtracted from the observed delay
- From observation files (default)
- From External files
 - Stored at ../ION/
 - Must be created in advance
 - VieVS tool to create them based on global TEC maps
 - http://viewswiki.geo.tuwien.ac.at/doku.php?id=public:vievs_manual:data#external_ionospheric_files

Station corrections (1)

Vienna VLBI and Satellite Software 3.1

File **Models** Estimation Global solution Scheduling Simulation Run Plotting Help

Station corrections

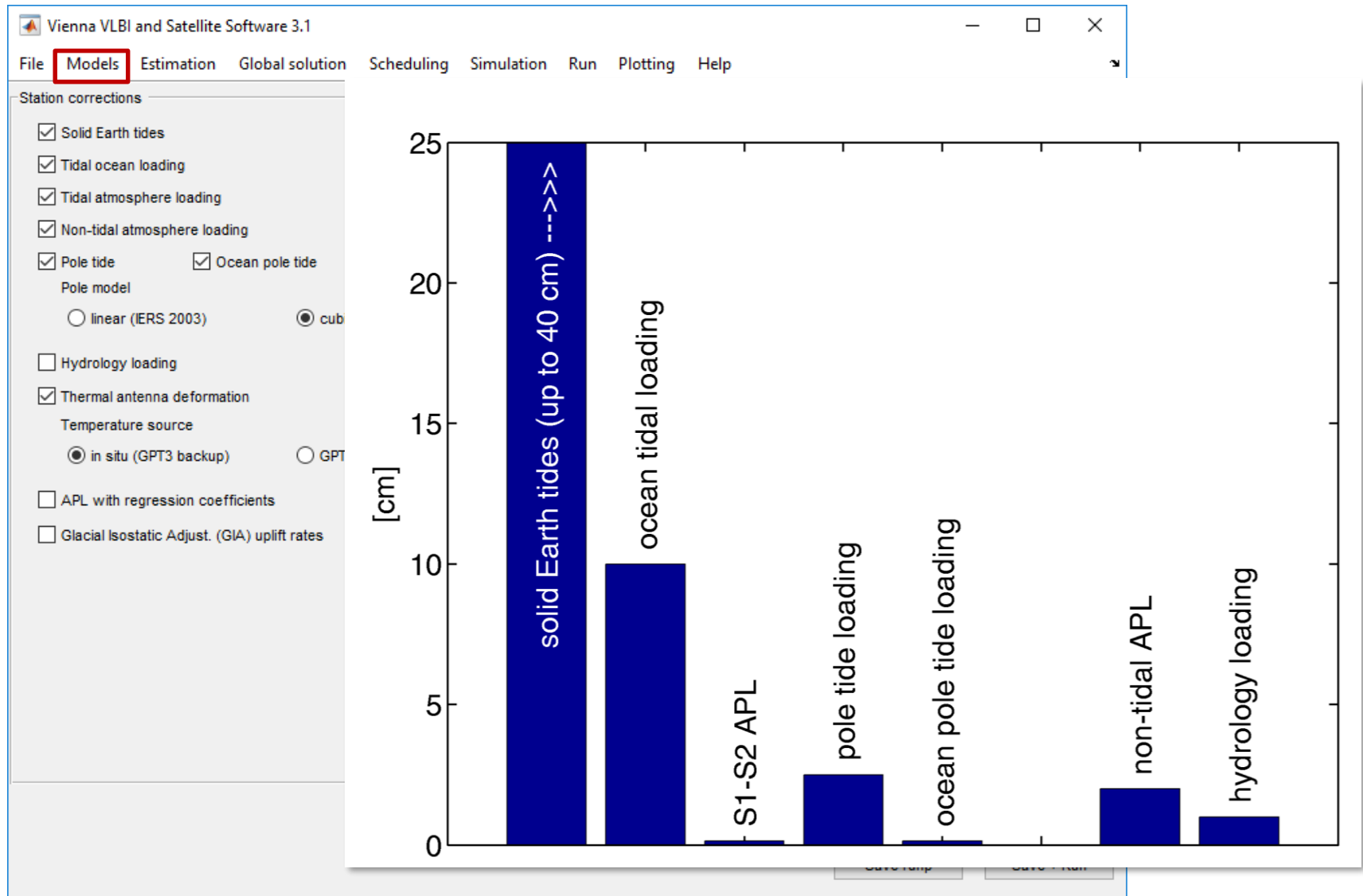
- Solid Earth tides
- Tidal ocean loading FES2004
- Tidal atmosphere loading vienna
- Non-tidal atmosphere loading APL_VIENNA
- Pole tide Ocean pole tide
- Pole model
 - linear (ERS 2003)
 - cubic (ERS 2010)
 - ERS 2015
- Hydrology loading ERAHYD
- Thermal antenna deformation
- Temperature source
 - in situ (GPT3 backup)
 - GPT3
- APL with regression coefficients p0_RCexternal
- Glacial Isostatic Adjust. (GIA) uplift rates ICE_5G_VM2_2012 (creates a GIA-free TRF within Vie_GLOB)

Save run Save + Run

Station corrections:

- Solid Earth tides
- Various tidal/non-tidal loading effects of atmosphere and oceans
 - Different models
- Pole tides
- Thermal deformation of the antenna structure
- Advanced options
 - APL with regression coeff.
 - GIA rated

Station corrections (2)



EOP (1)

Vienna VLBI and Satellite Software 3.1

File **Models** Estimation Global solution Scheduling Simulation Run Plotting Help

EOP

A priori time series

- 08 C04 (IAU2000)
- 14 C04 (IAU2000)
- finals (IAU2000)
- from txt file C04_08_1962_now.txt
- include a priori celestial pole offsets

Models

Include high frequency

- Ocean tides interpf (Conventions)
- Libration (xp, yp) 10 terms
- Libration (UT1) 11 terms

Precession/Nutation model

- IAU 2000A
- IAU 2006/2000A

Interpolation

- linear
- lagrange

Tidal UT variations (RG_ZONT2)

- UT1R <35d
- UT1S all constituents

Save_runn Save + Run

*<http://www.iers.org/iers/EN/DataProducts/EarthOrientationData/eop.html>

A priori time series:

- From IERS webpage*
- Daily values
- **xx C04**
 - Long term solution, high accuracy
 - Updated two times/week
 - Longer latency!
- **Finals**
 - „Rapid“ solutions, lower accuracy
 - Updated daily
 - Necessary for recent sessions, e.g. int
- **From „self-created“ EOP text file:**
 - ../EOP/*.txt
 - Watch format!
- Include/exclude dX/dY from EOP a priori table

EOP (2)

Vienna VLBI and Satellite Software 3.1

File **Models** Estimation Global solution Scheduling Simulation Run Plotting Help

EOP

A priori time series

08 C04 (IAU2000)

14 C04 (IAU2000)

finals (IAU2000)

from txt file C04_08_1962_now.txt

include a priori celestial pole offsets

Models

Include high frequency

Ocean tides interpf (Conventions)

Libration (xp, yp) 10 terms

Libration (UT1) 11 terms

Precession/Nutation model

IAU 2000A

IAU 2006/2000A

Interpolation

linear

lagrange

Tidal UT variations (RG_ZONT2)

UT1R <35d

UT1S all constituents

Save runp Save + Run

Models:

- Add high frequency EOP corrections
 - Ocean tides:
 - Diurnal & semidiurnal variations in UT1 and xp/yp
 - Different models
 - Libration:
 - Diurnal xp/yp and semidiurnal UT1 corrections
- Precession/Nutation Model

EOP (3)

Vienna VLBI and Satellite Software 3.1

File **Models** Estimation Global solution Scheduling Simulation Run Plotting Help

EOP

A priori time series

- 08 C04 (IAU2000)
- 14 C04 (IAU2000)
- finals (IAU2000)
- from txt file
- include a priori celestial pole offsets

Models

Include high frequency

- Ocean tides
- Libration (xp, yp) 10 terms
- Libration (UT1) 11 terms

Precession/Nutation model

- IAU 2000A
- IAU 2006/2000A

Interpolation

- linear
- lagrange

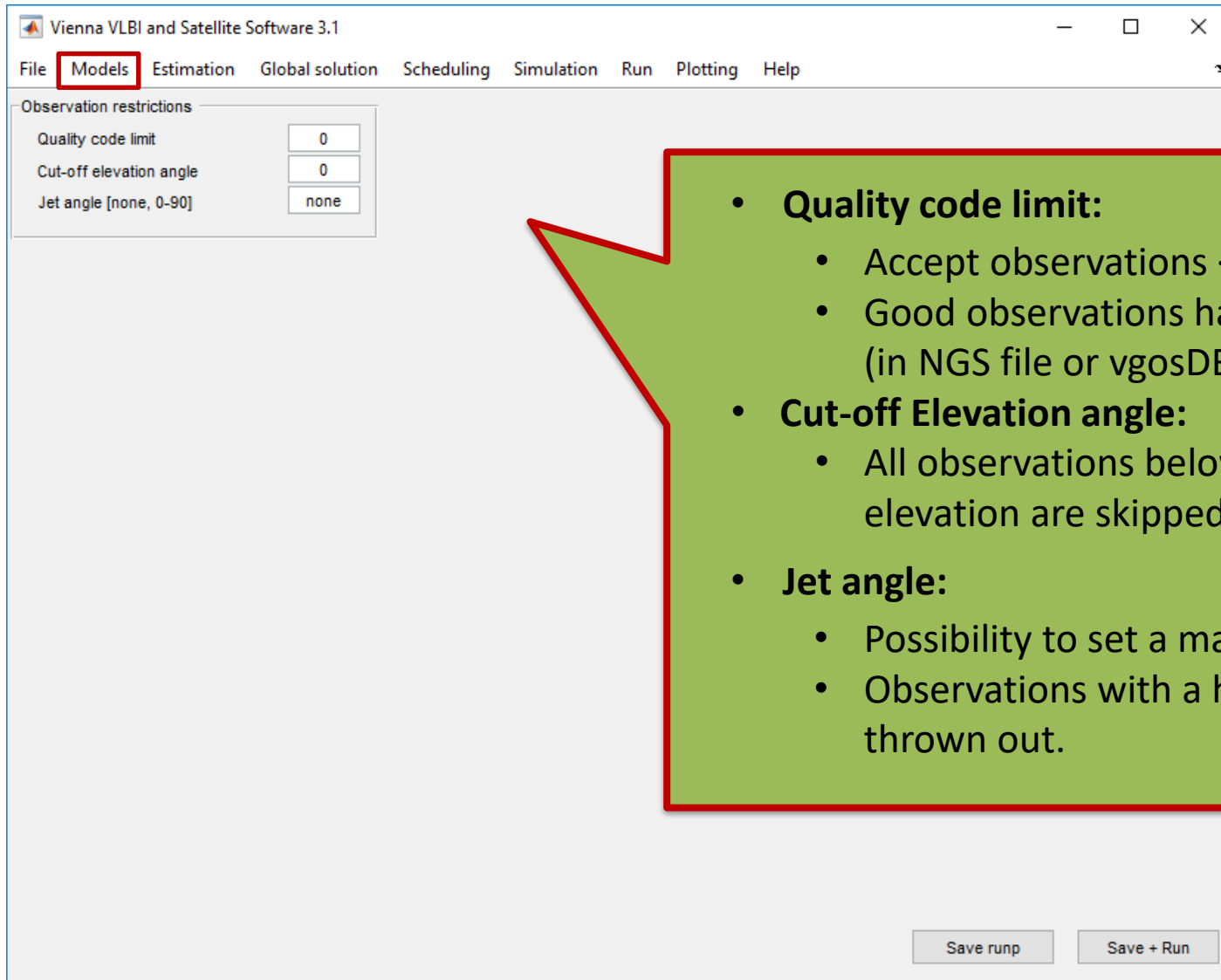
Tidal UT variations (RG_ZONT2)

- UT1R <35d
- UT1S all constituents

Interpolation of EOP:

- **Lagrange:**
 - Window of 4 data points
- **Linear:**
 - Interpolation between the midnight before and after observation time.
 - For a session from 18:00 to 18:00 this means, that there are 2 a priori lines and a break at midnight.
- **Tidal UT variations:**
 - Removed before and re-added after interpolation
 - „Smooth“ UT1 series for interpolation

Observation restrictions



The screenshot shows the 'Models' menu in the Vienna VLBI and Satellite Software 3.1 application. The 'Observation restrictions' panel is visible, containing three settings:

Parameter	Value
Quality code limit	0
Cut-off elevation angle	0
Jet angle [none, 0-90]	none

At the bottom of the window, there are two buttons: 'Save runp' and 'Save + Run'.

- **Quality code limit:**
 - Accept observations \leq defined limit
 - Good observations have quality code 0 (in NGS file or vgosDB database)
- **Cut-off Elevation angle:**
 - All observations below this local elevation are skipped
- **Jet angle:**
 - Possibility to set a max. jet angle
 - Observations with a higher angle are thrown out.

Source structure

Vienna VLBI and Satellite Software 3.1

File **Models** Estimation Global solution Scheduling Simulation Run Plotting Help

Source Structure

Catalog

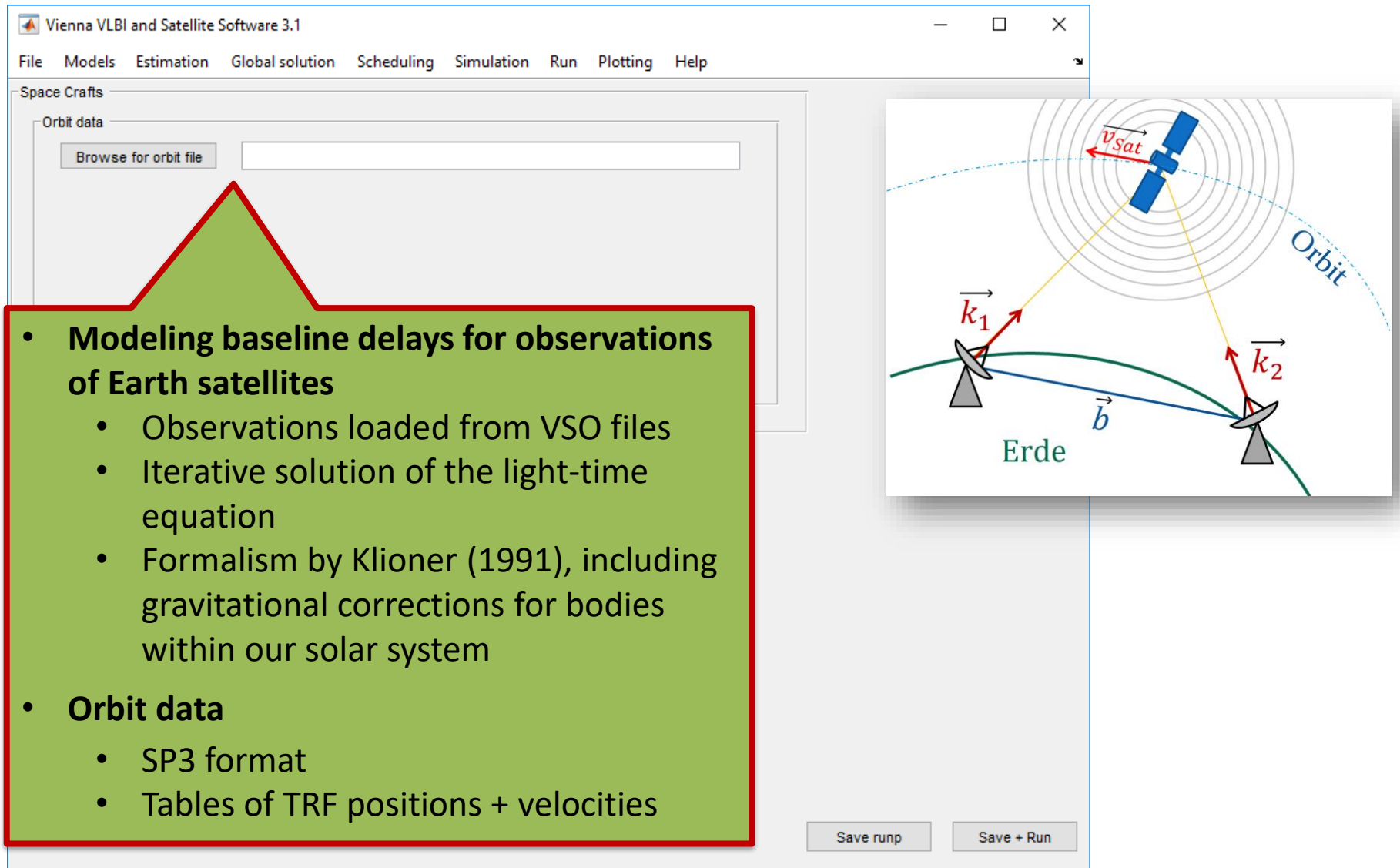
Apply Source Structure Correction

write jet angles

- **Catalogs**
 - containing source structure data
 - .../CRF/SOURCE_STRUCTURE_CAT/*.cat
- **Apply source structure correction**
 - Computed delay is corrected for source structure effects
- **Write jet angles**
 - Jet angles for each observation are written to:
.../DATA/JETANG/session(1:9).JET

Save runp Save + Run

Space crafts



The screenshot shows the 'Vienna VLBI and Satellite Software 3.1' application window. The 'Space Crafts' panel is active, displaying an 'Orbit data' section with a 'Browse for orbit file' button. A green callout box with a red border contains the following text:

- **Modeling baseline delays for observations of Earth satellites**
 - Observations loaded from VSO files
 - Iterative solution of the light-time equation
 - Formalism by Klioner (1991), including gravitational corrections for bodies within our solar system
- **Orbit data**
 - SP3 format
 - Tables of TRF positions + velocities

To the right of the callout box is a diagram illustrating the geometry of satellite observations. It shows a satellite in orbit around Earth (labeled 'Erde'). The satellite's position is defined by its velocity vector \vec{v}_{Sat} and its orbit. Two ground stations on Earth are shown, with their positions relative to each other defined by the baseline vector \vec{b} . The unit vectors from the ground stations to the satellite are labeled \vec{k}_1 and \vec{k}_2 . The diagram also shows the Earth's surface and the satellite's orbit.

At the bottom of the software window, there are two buttons: 'Save runp' and 'Save + Run'.

Demonstration

- Run session in VieVS!
 - 18JUL23XA (vgosDB)

Results

- **Computed delay times** τ_{comp}
- **Partial derivatives** $\frac{\partial \tau}{\partial VAR}$
- **Results are stored in** .../DATA/LEVEL1/<session name>_antenna
_parameter
_scan
_sources

(http://viewswiki.geo.tuwien.ac.at/doku.php?id=public:views_manual:important_files#views_data_structures)

➔ **Used as input for VIE_LSM**

- **Vie_Mod models....**
 - Computed (theoretical) delay times τ_{comp}
 - Partial derivatives $\frac{\partial \tau}{\partial VAR}$
- **Modelling in agreement with IERS Conventions**
- **For more information...**
 - Check the code (main function: *vie_mod.m*)
 - Detailed documentation: .../DOC/vie_mod.pdf
 - VieVS-Wiki
http://viewswiki.geo.tuwien.ac.at/doku.php?id=public:views_manual:input_parameters