Exercise 1: Analyze a session

First look at session

To get a general idea about the session you can go to the IVS homepage where all the information about sessions run by the IVS is stored. http://lupus.gsfc.nasa.gov/sess/sesshtml/2016/r1741.html

Find the session:

Select *File/set input files,* press on *Browse for sessions* and find the session 16MAY23XA_N004.

Select output directory:

Go to *Run/Run options* and specify an output directory (Sub-directory for (intermediate) results)

Press *Save + Run*

Inspect output

In the output in the command window you should see indicators of session quality

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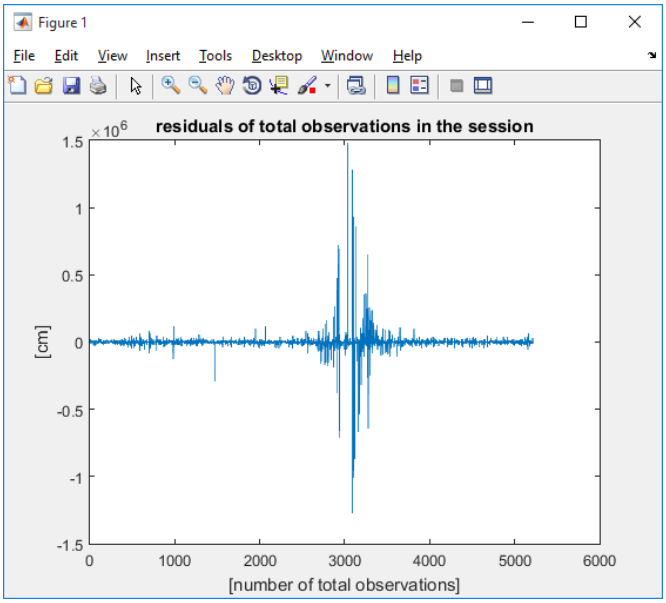
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

chi-squared of main solution vTPv/degOfFreedom: 4303448969.328

WRMS of post-fit residuals sqrt(v_realTPv_real/sumOfWeights): 76121.726 cm (2539147.452 ps)

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

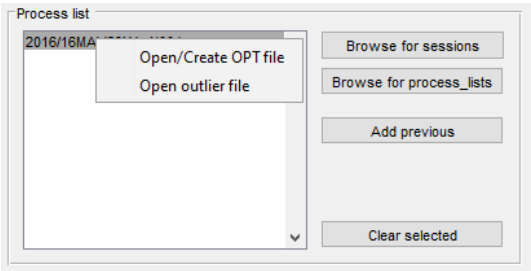
Chi^2 indicates how well you model fits your observations, it should be around 1. The WRMS of your post-fit residuals should be around 30 for a typical R1 or R4 session. VieVS provides a plot of the residuals at the end of the least squares matching. The residuals should be normally distributed. We can clearly see that something went wrong.



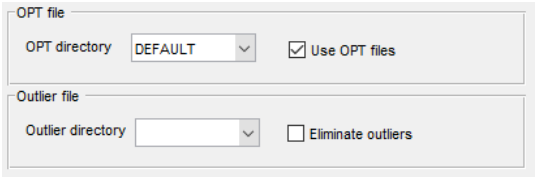
Error investigation:

OPT file

With this file you can specify certain options which are then applied to the session it corresponds to by VieVS. A quick way to open the OPT file is to right click on the session selection and select *Open/Create OPT file.*



An empty OPT file will appear (it will be saved in the folder you selected in *OPT directory*).



Alternatively you can find the OPT file in the directory *VieVS/DATA/OPT/selected directory/year of session.*

The syntax of the OPT file is quite self-explanatory. Examples are provided in the comment part of the OPT file.

Before we can set our option in the OPT file we have to find the cause of error with the plotting tool provided by VieVS.

Go to *Plotting/Residuals* and select your folder and session.

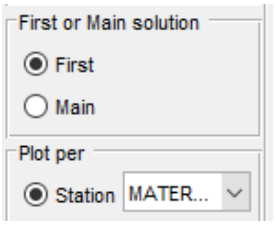
Look for clock breaks

A good way to find clock breaks is the so called first solution because it approximates the clock only as one offset, one rate & one quadratic term (no PWLO are calculated which would follow the clock break behavior and would therefore mask it in the residuals).

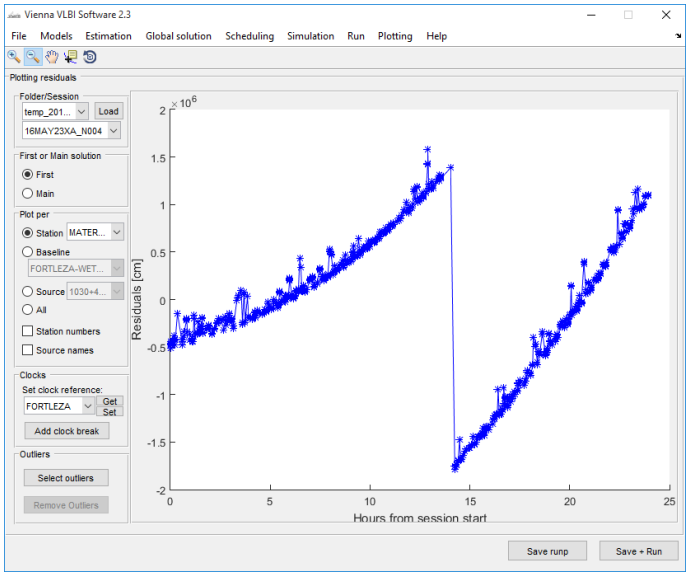
First solution

In geodetic VLBI we estimate very small quantities (e.g. corrections for EOP, station coordinates, etc.) alongside large quantities (clock offsets). Including all of them into the same matrix can produce numerical instabilities. The solution for this problem is the so called first solution. Basically, we fix all the small quantities and only estimate the large ones in a first run. Then we add these large quantities to out a priori model effectively bringing all the estimates into the same range. We then can execute our main solution.

Select the *first solution* radio button and browse through the residuals per station.

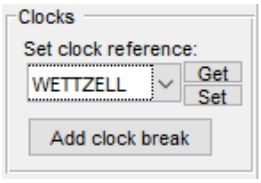


If you find a station with a clear jump in the residuals you probably found a clock break. In this case MATERA has a large jump.



In order to select the time for the clock break we have to zoom in using the magnifying glass symbol on the upper left of the GUI. When we sufficiently zoomed in we can click the *add clock break* button and click exactly on the clock break (between observations). Click on *Yes* and the clock break is written to your OPT file.

It is always a good idea to set your own reference clock to a station which is known to have a stable clock, such as WETTZELL. Otherwise VieVS will use the first station in the list as reference. You can do that by selecting the station you want and click *Set*.



Run the session again using your OPT file. Don't forget to select *Use OPT files* in the *Files/set input files* GUI.

Look again into the first solution per station. We can't see any clock breaks anymore but some huge outliers are present in the residuals of MATERA, WARK12M and HOBART12. This indicates that something went wrong with these baselines (this effect is only present on very sparsely observed long baselines).

Find erroneous baselines

Look through the residuals per baseline. Pay attention to the scale of the y axes. We can see that two baselines have very high residuals (10^4-10^5) and very few observations. These are MATERA-WARK12M and MATERA- HOBART12. This corresponds to the stations with large outliers mentioned before. Remove these baselines by modifying the OPT file, type:

```
BASELINES TO BE EXCLUDED: 2
MATERA WARK12M
MATERA HOBART12
```

The residuals look more or less normally distributed now.

Find erroneous stations

Sometimes stations have problems and their data has to be deselected. This can be done in the OPT file by typing:

```
STATIONS TO BE EXCLUDED: 1
NYALDBBC
```

In our case the station NYALDBBC has to be deselected. The reason for this is that the station NYALES20 used two backends to record the same data. This is usually done for testing purposes.

Other useful options

One can specify a time span next to a deselected station. This will remove all the data from this station in that time span.

Problematic sources can be deselected (also per time span) as well.

Another option in the OPT file for problematic stations (e.g. higher noise level) is to down-weight them.

Sometimes the cable calibration of stations is wrong (jumps, only noise etc). If that's the case you have to deselect it. This is mainly a problem when "manual pcal" is used. You can find the plots of cable calibration on the IVS webpage mentioned in the beginning of this exercise.

Outlier test

In the end it is always useful to check your solution for outliers. Outliers are stored in a text file which can be accessed similarly to the OPT file (right click etc).

First we have to find the outliers. We can do that manually by using the select *outliers* button in the *Plotting/Residuals* GUI. Or we can do it automatically by going to *Run/VieVS estimation settings* and click on *simple outlier test*.

Use the automatic outlier detection and press run. VieVS finds 23 outliers and writes them to VieVS*/DATA/OUTLIER/year of session/session name.OUT.*

Attention: These outliers are only detected, not removed. To remove the outliers deselect the *simple outlier* check box and select the *Eliminate outliers* check box in the *File/Select input files* GUI and run the session again.

The output should be normally distributed and the quality indicators should be in a reasonable range.