Journal of Georgian Geophysical Society,
Issue (A), Physics of Solid Earth, v.15a, 2011-2012, pp. 42-48

SEISMOTOOL – easy way to see, listen, analyze seismograms

T. Chelidze[1], N. Zhukova[1], T. Matcharashvili[1]

M. Nodia Institute of Geophysics at the I. Javakhishvili Tbilisi State University,1 Alexidze str, Tbilisi, 0171, Georgia

Corresponding author: Prof. Tamaz Chelidze, Chairman of the Scientific Council
M. Nodia Institute of Geophysics at the I. Javakhishvili Tbilisi State University,1 Alexidze str, Tbilisi, 0171, Georgia
Ph: (995 32) 233 28 67; Fax: (995 32) 233 28 67
E-mail: tamaz.chelidze@gmail.com;
Mobile : + 995 577 79 07 45

*Online material: E*xecutive programs: SEISMOTOOLS.exe, seisfilt.exe, seisspectro.exe; sample data sets are presented in the folder examples.

In the 2012 March/April issue of SRL in the paper of D. Kilb et al (2012) the SeisSound package for listening, watching and learning seismic records using methods which allow "communicate effectively with diverse audiences who have a variety of learning styles and level" was presented.

SEISMOTOOL package presented in this paper is a convenient instrument to watch, listen and even analyze seismic records in easy way. Frequency content of seismic records (20 Hz-20 kHz) is too low to be taken by humans. The simplest way to listen seismic records is to compress time (accelerate audio playing by changing sampling rate), which was realized in the (Kilb et al, 2012, Peng et al, 2012).

Advantage of the program presented in our paper in comparison with the application running under MATLAB environment, such as in the SeisSound package (Kilb et al, 2012) is a possibility to process long data files, glue recordings, extract recording segments, change compression rate and filter records. In MATLAB environment used in SeisSound the data are loaded in the block of memory used by MATLAB, which has limited capacity. As a rule, digital seismic data files are long, for example, if the sampling rate of record is 100 Hz, 1 day seismogram includes 8 640000 samples and takes 67500 kilobytes in memory if the type of data is double or integer. SEISMOTOOL loads data into a computer memory directly, therefore it can process longer data sets.

SEISMOTOOL can "glue together "seismograms, for example, merge hourly seismograms into daily ones, etc. It converts seismograms to acoustic signals (16 bit wav files), which allow "listen to earthquakes". As there are many programs for processing an acoustic signal, using this opportunity we can easy watch, listen and process long seismograms converted to acoustic signals. For example, it is possible to use different time scales (compression rates), which is impossible to do in the SeisSound.

There here are 2 options to process data: SEISMOTOOL package creates mono or stereo wav file. For example, we can create stereo wav file, where 1st and 2nd channels are original and filtered seismograms. Second example: stereo wav file can be composed from seismograms recorded at 2 different stations. 4th order Butterworth bandpass filter is implemented into SEISMOTOOL application. The filter was extracted from MATLAB signal toolbox and compiled as the standalone

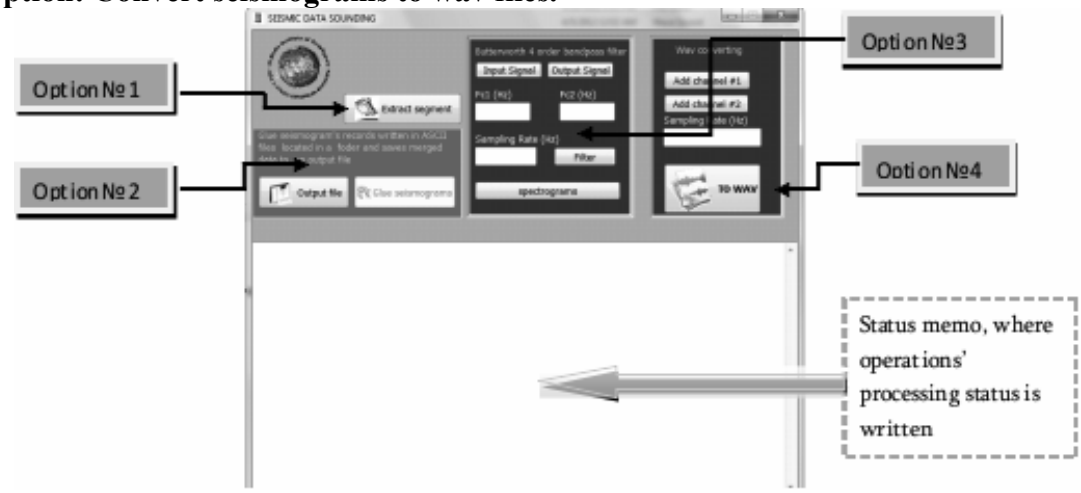
application. For the filtering and spectrogram running it is only necessary to install MATLAB Run Time Compiler if MATLAB is not installed on computer system. (This library can be downloaded free from http://www.mathworks.com/products/compiler/). Users have option to select the frequency range, which filter passes. Sony Sound Forge software was selected as an instrument to both process seismograms and listen to earthquakes vibrations. Sound Forge allows editing wav data, change time scale on time axis to see details of seismograms, analyzing segments of recording, etc. This tool is very useful for fast identification of triggered tremors generated by passing wave trains from remote strong earthquakes, which is now a hot topic in seismology (Hill, Prejean, 2009; Prejean, Hill, 2009).

The package includes examples' data (**input.dat** and folder **seism** with hourly seismogram files) which were used to demonstrate program capacity. MATLAB Run Time Compiler (**MCRInstaller**) also is provided in the package. Attention: seisfilt.exe and seisspectro.exe programs must be located in the same folder with SEISMO.exe

PROGRAM RUN

SEISMO application has 4 independent options (See picture bellow)**:**

1. **Option: Extract segments from seismograms;**
2. **Option: Glue together seismograms;**
3. **Option: Filter seismograms by band-pass filter and plot spectrogram of original and filtered seismic series, spectrogram's plotting;**
4. **Option: Convert seismograms to wav files.**



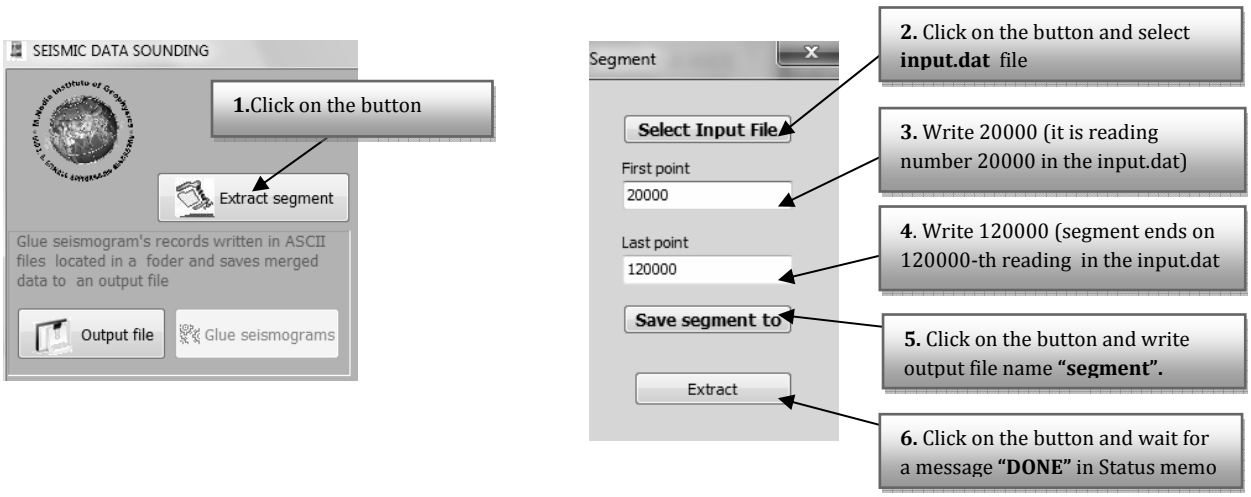
All options are independent. Each operation can be executed separately. If it's needed just to filter seismograms only the filter panel (Option №3) is to be called.

Option 1: Extract segment

This operation is used when we want to extract some segment from the whole seismograms.

1. Click on button **Extract segment**;
2. In the appeared dialog window select an input file with seismogram;
3. Indicate in field **First point** the first position in a seismogram from which extract segment begins;
4. Indicate in the field **Last point** last extracting -position in an input seismogram;
5. Click on button **Save segment to** and write the output file name for a selected segment;
6. Click on button **Extract** and wait for a message "**DONE**" in the Status memo.

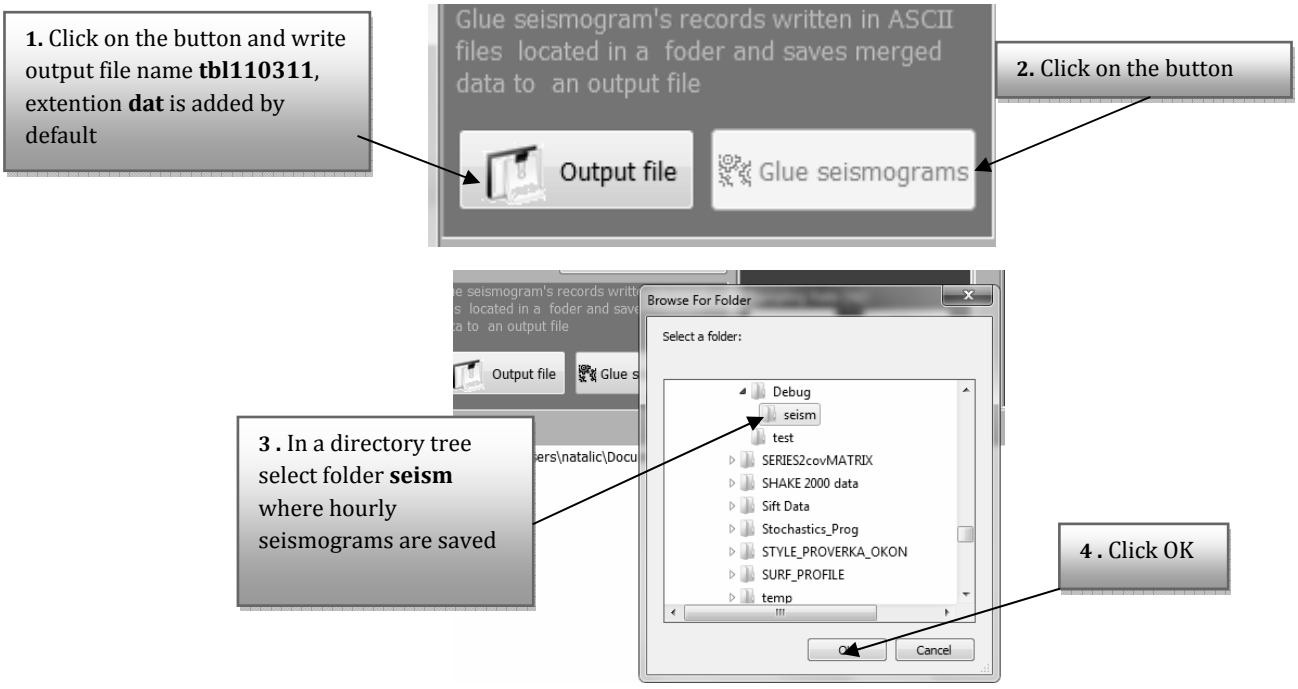
Example: *from the file "input.dat" we need to extract segment (20000:120000) and save it to a file "segment.dat".*



<u>Option 2: Glue seismograms</u> (If seismograms are split into several files there is an option to merge seismic records and process long seismograms).

1. Click on **Output File** button and indicate output file name. (Directory of output file and directory of input seismogram files must be different);
2. Click on the button **Glue seismograms** and indicate folder with the seismogram record files.
3. ***Example.*** *We have directory "seism" with hourly recorded seismograms, we want to glue these seismograms and obtain one day seismogram saved to the output file "tbl110311.dat".* ***Notation:*** *the output file* ***tbl110311.dat*** *will be written to different from "seism" directory*

In **Status Memo** we will see a work execution process:

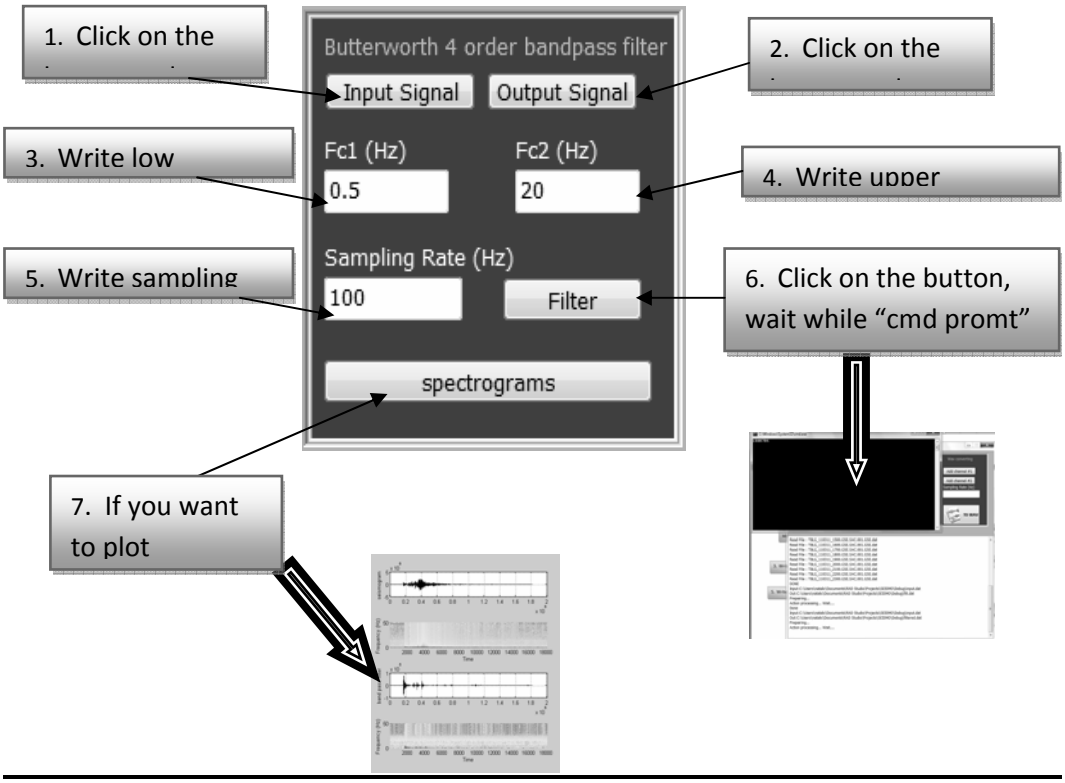


```
Output file C:\Users\natalic\Documents\RAD Studio\Projects\SEISMO\Debug\tbl110311.dat
Directory for reading: C:\Users\natalic\Documents\RAD Studio\Projects\SEISMO\Debug\seism
Sorting list of files....
File number for listing = 23
Read File : TBLG_110311_0100.GSE.SAC.002.GSE.dat
Read File : TBLG_110311_0200.GSE.SAC.001.GSE.dat
Read File : TBLG_110311_0300.GSE.SAC.001.GSE.dat
Read File : TBLG_110311_0402.GSE.SAC.001.GSE.dat
……..
Read File : TBLG_110311_2000.GSE.SAC.001.GSE.dat
Read File : TBLG_110311_2100.GSE.SAC.001.GSE.dat
Read File : TBLG_110311_2200.GSE.SAC.001.GSE.dat
Read File : TBLG_110311_2300.GSE.SAC.001.GSE.dat
DONE    (←means that operation is finished)
```

Option 3: Band pass filter

1. Click on **Input Signal** and select a file with seismogram;
2. Click on **Output Signal** and indicate a file name for filtered seismogram;
3. In the fields **Fc1** and **Fc2** indicate bandpass frequency range (in Hz). Notation: **Fc1** and **Fc2** should be less than half of record sampling rate;
4. In the field **Sampling Rate** indicate sampling rate (in Hz) of a seismic signal;
5. Click on **Filter** button and wait for the end of the operation. If everything is OK, command window will appear and after its closing a file with filtered seismogram will be created;
6. Optionally. Plot spectrogram of original and filtered seismograms.

Example: *We want to filter seismogram in the frequency range: (0.5-20Hz). The seismogram is recorded at the sampling rate 100 Hz and saved in the file "input.dat". Filtered seismogram will be saved to the file "filt.dat"*

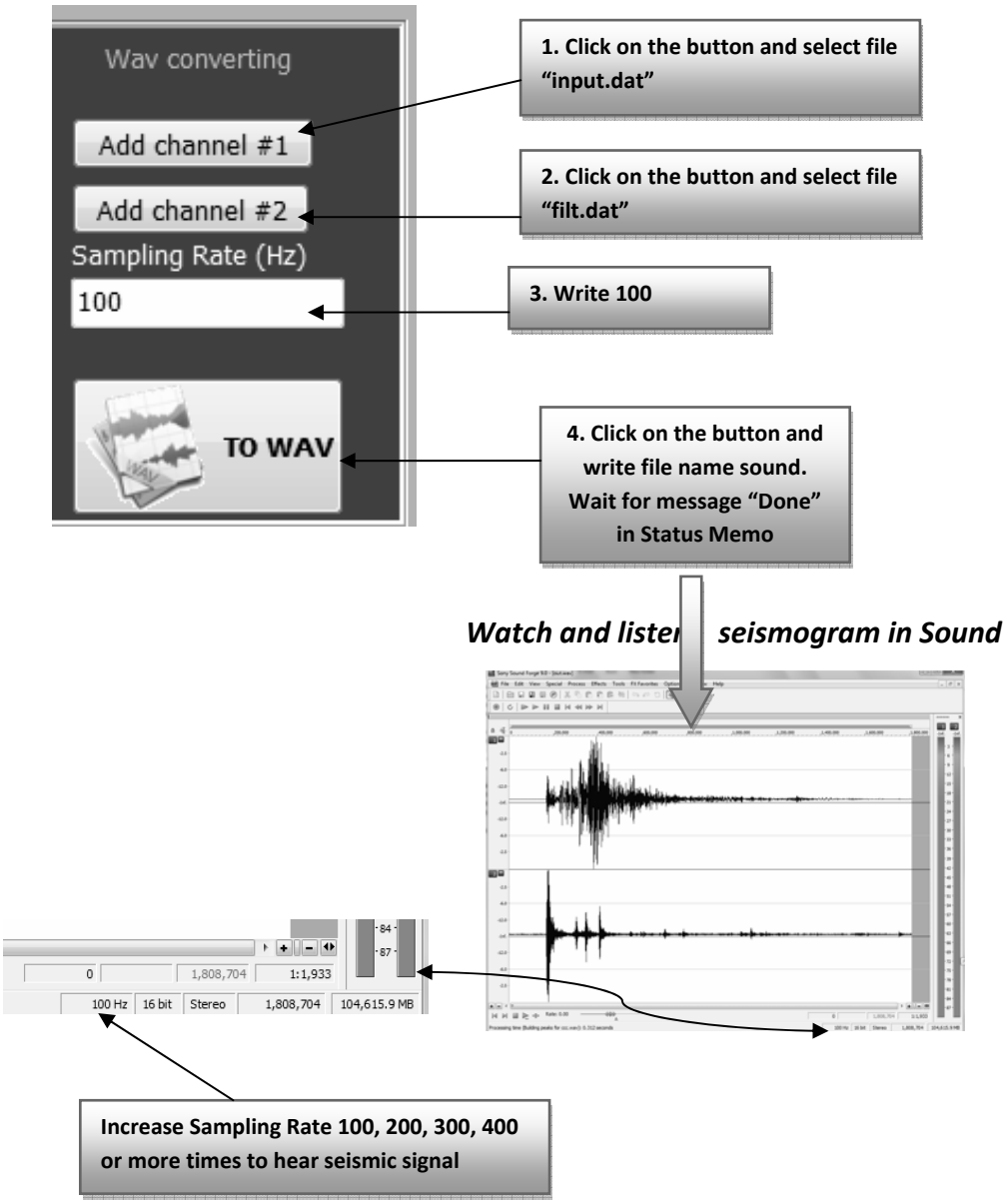


Option 4: Convert seismogram to a Wav file

1. Click on **Add channel #1** and select input file with a seismogram;
2. Click on **Add channel #2** and select input file with a filtered seismogram;
3. In the field **Sampling Rate** indicate sampling rate (in Hz) of a seismic signal;
4. Click on **To WAV** button and indicate output wav file name. Wait when operations will be finished.

If the channel #2 is not selected only mono file will be created.

***Example**: we want to convert original and filtered seismograms saved in file "input.dat" and "filt.dat" to stereo wav file with the name "sound.wav". 1st channel will represent original seismogram, 2nd channel – filtered one. Seismogram is recorded with sampling rate 100 Hz.*



We presume that presented package will render to wide public an easy way to understand earthquake recordings and will be an useful addition to package of Kilb et al. (2012).

Acknowledgments: Authors acknowledge financial support of European Centre "Geodynamical Hazards of High Dams" operating in the frame of Open Partial Agreement on Major Disasters at the Council of Europe**.**

(Received in final form 13 December 2012)

References:

[1] Chelidze, T.,T. Matcharashvili, O. Lursmanashvili, N. Varamashvili and N. Zhukova, E. Meparidze. 2010. Triggering and Synchronization of Stick-Slip: Experiments on Spring-Slider System. In: *Geoplanet: Earth and Planetary Sciences, Volume 1*, 2010, DOI: 10.1007/978-3-642-12300-9; *Synchronization and Triggering: from Fracture to Earthquake Processes*. Eds.V.de Rubeis, Z. Czechowski and R. Teisseyre, pp.123-164

[2] Kilb, D., Z. Peng, D. Simpson, A.Michael, M. Fisher, and D. Rohrlick. Listen, Watch, Learn: SeisSound Video Products. *Seismological Research Letters,* 83 (2), 2012, 281-286.

[3] Peng, Z., C. Aiken, D. Kilb, D. R. Shelly, and B. Enescu (2012). Listening to the 2011 magnitude 9.0 Tohoku-Oki, Japan, earthquake.*Seismological Research Letters* 83(2), 287–293.

[4] Hill, D. 2010. Surface wave potential for triggering tectonic (nonvolcanic) tremor. *Bull. Seismol. Soc. Am.* 100, 1859-1878, doi: 10.1785/0120090362.

[5] Hill, D., Prejean, S. 2009. Dynamic triggering. In: *Earthquake Seismology*. Volume editor H. Kanamori. *Elsevier*. pp. 257-293.

[6] Prejean S., Hill, D. 2009. Dynamic triggering of earthquakes. In: *Encyclopedia of Complexity and Systems Science*, R. A. Meyers (Ed.), Springer, pp. 2600-2621.

(Received in final form 20 December 2012)

СЕЙСМО-ТУЛ – метод для визуализации, прослушивания и анализа сейсмограмм.

Тамаз Челидзе, Наталия Жукова, Теймураз Мачарашвили

Резюме

Предлагается компьютерная программа для визуализации, прослушивания и анализа сейсмограмм, позволяющая с использованием пакета Sony Sound Forge и элементов МАТЛАБ-а (а именно MATLAB Run Time Compiler) обрабатывать большие объемы данных, соединять или наоборот, вырезать различные участки записи, изменять ее временной масштаб и проводить фильтрацию. Программа может использоваться для популяризации и образования, например, она дает возможность «прослушивать» землетрясения путем перевода сейсмической записи в акустический диапазон.

სეისმო-ტული - ადვილი გზა სეისმოგრამების ვიზუალიზაციისათვის, მათი მოსმენისა და ანალიზისათვის

თ. ჭელიძე, ნ. ჟუკოვა, თ. მაჭარაშვილი

რეზიუმე

შედგენილია კომპიუტერული პროგრამა სეისმოგრამების ვიზუალიზაციისათვის, მათი მოსმენისა და ანალიზისათვის, რომელიც პაკეტის Sony Sound Forge და მატლაბ-ის ელემენტების (კერძოდ, MATLAB Run Time Compiler) გამოყენებით საშუალებას იძლევა დავამუშავოთ დიდი მოცულობის მქონე მონაცემთა მწკვრივები, შევაერთოთ ან პირიქით, ამოვჭრათ ჩანაწერის სხვადასხვა მონაკვეთები, შევცვალოთ ჩანაწერის დროითი მასშტაბი ან გავფილტროთ იგი. პროგრამა გამოიყენება როგორც პოპულარიზაციის, ისე საგანმანათლებლო მიზნებით, მაგალითად მისი საშუალებით შესაძლოა მიწისძვრის „მოსმენა“ თუ გადავიყვანთ სეისმურ ჩანაწერს აკუსტიკურ დიაპაზონში.