Tuned in to Mars from the schools

when the French Seismological Educational Network participates to the SEIS InSight blind test

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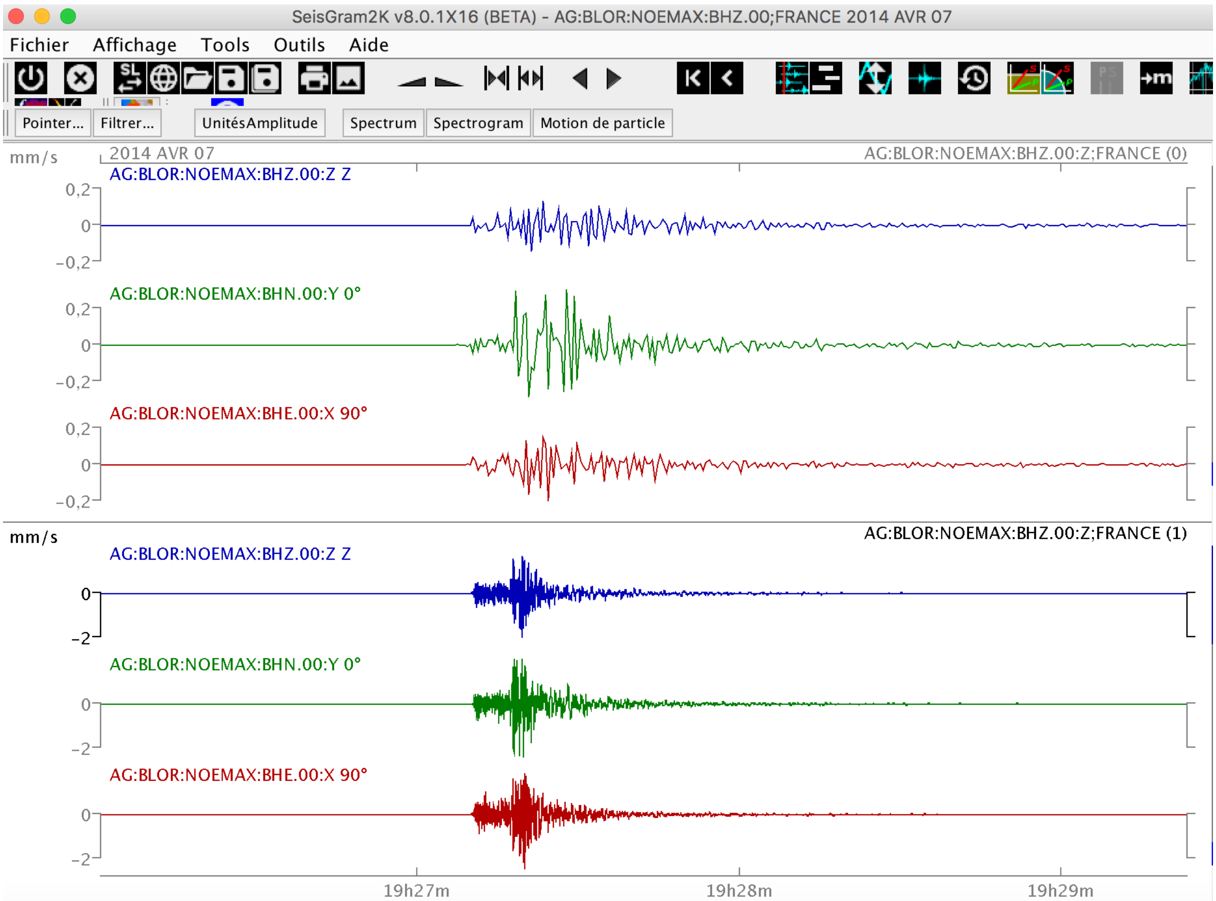
When the blind test operation was initiated in the scientific community, we suggested to the schools to participate in this challenge. Fifteen schools accepted the challenge which consisted in analysing one month of data of the test blind and in detecting seismic events. For schools, the priority was the educational approach to follow, more than the final catalogue (that is a very difficult exercise for the pupils).
Each school had to study one month of the blind test data.

We recommended to the teachers an approach in several steps.

STEP 1: Sampling the signal and analysing the seismograms
Pupils had to compare seismograms with different sampling frequencies (50 Hz and 2 Hz) for local, regional and faraway Earthquakes events.

Conclusion > Pupils notice the signal to 2 Hz can be rather different than the signal to 50 Hz. The decimation can also modify the amplitude of the seismograms. Three components remain very useful to identify the volume waves P and S.

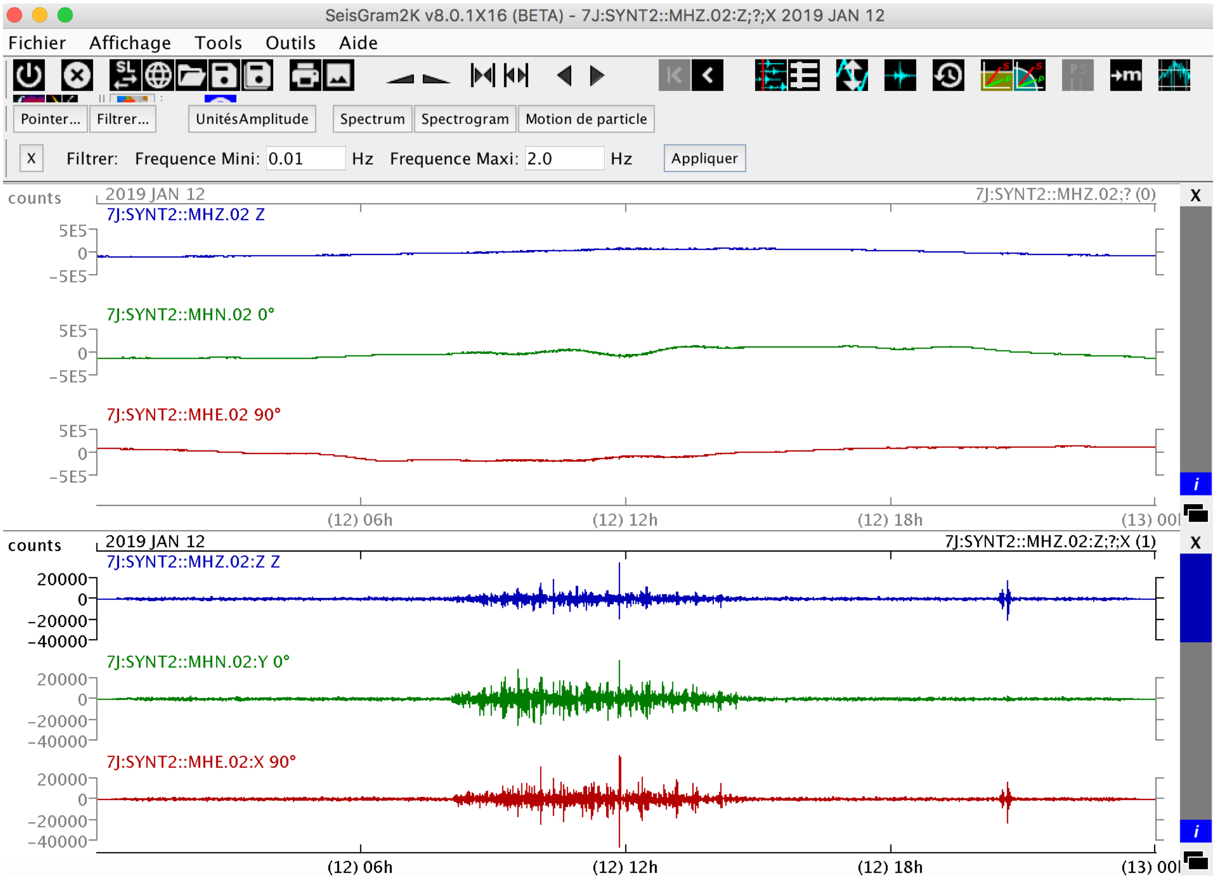


Example with two seismograms (2 Hz – Up and 50 Hz – below) seismic event Barcelonnette 2017.04.07 recorded à 70 km from the epicentre.

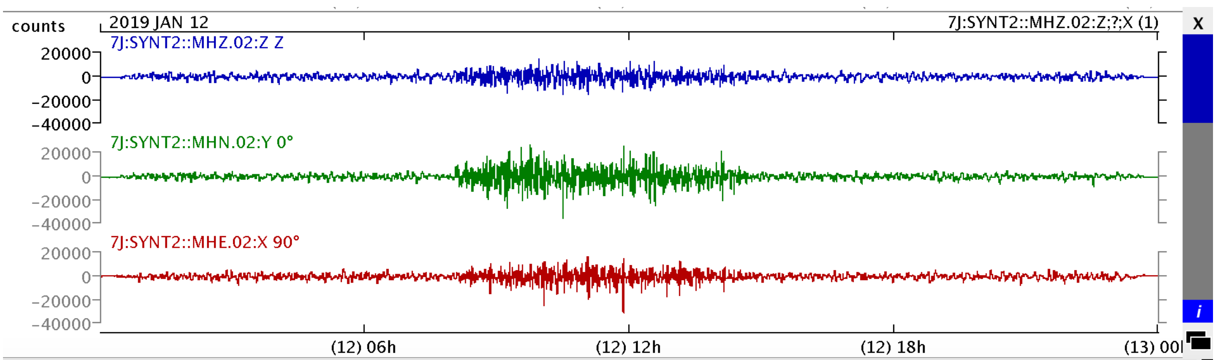
STEP 2: The frequency contents of the signal

The identification of the seismic events brings us to analyse the frequency contents of the signal. It is necessary, at first, to try to subtract the noise linked to the environment of the sensor like pressure, temperature, wind variations.

The software SeisGram2K© (school version SeisGram2K.80_ECOLE.jar by Anthony Lomax) allows to apply filters to the signal, and so to estimate if we look at disturbances due to the environment, either seismic waves vibrations.
Once the data filtered (between 0.01Hz to 1.0 Hz), the record is more comprehensive.



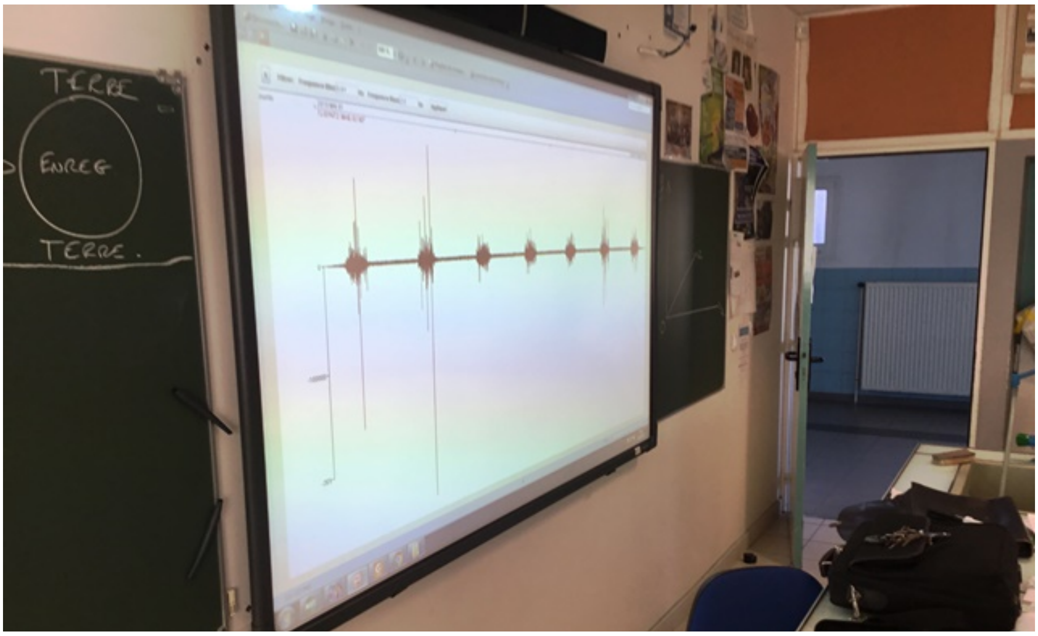
Example with one of the blind test file no filter (up) or filtered (below: 0,01 Hz to 1,0 Hz)



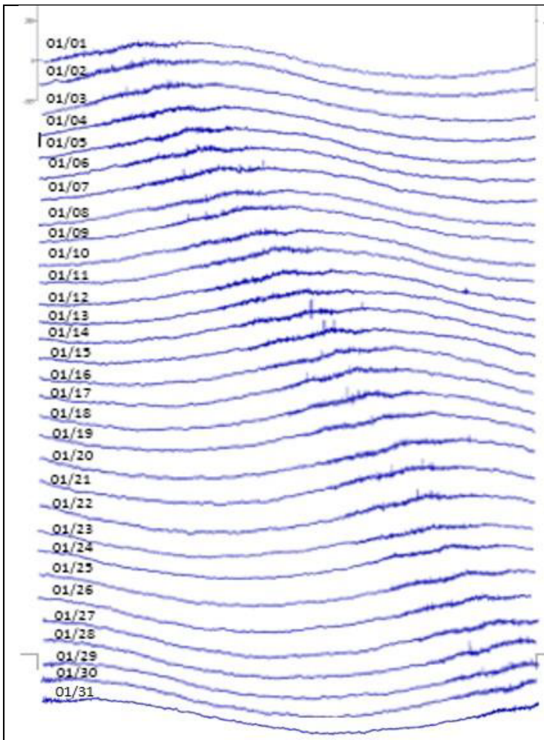
Example with the same data filtered (between 0.001 Hz and 0.1 Hz) … seismic event disappeared.

STEP 3: Daily noise recorded on the sensor.

Quickly, we notice, a noise on a window slot of 7 hours, every day, delayed for 40 minutes each day.



Example of record after concatenation of daily files *(Le Beausset city school).*



The analysis of the seismograms of January 2019 allowed to distinguish clearly daily noise. *(French school of Shanghai, China)*

This signal is the noise due to the movements of the atmosphere.

Off the beginning of the morning till the end of the afternoon, the atmosphere close to the surface on Mars is turbulent. In fact, the surface is warmed by the sun; there are movements of turbulence because of the convection with fast variations of wind, pressure and temperature …

At nightfall, the surface cools because it is not anymore brightened up. The convection stops.

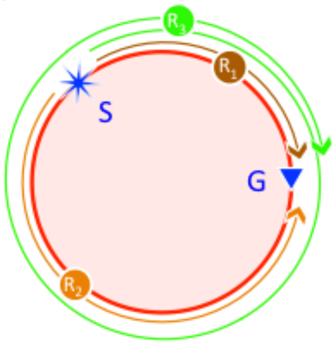
The significant turbulences begin towards 9h00-10h00 and end in 16h00-17h00 (daily window of 7 hours).

The Martian day lasts 24 hours and 40 minutes!

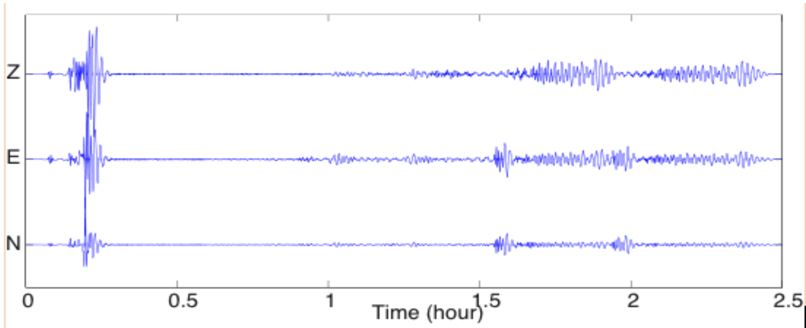
STEP 4: Determine the distance the seismic source and the seismometer

The mission InSight will explore the structure of the planet Mars with a single seismometer three components. How can we determine epicentral distance with one seismometer while on the Earth we use triangulation technique with at least three sensors?
The researchers plan to use a method by detecting travel time of Rayleigh surface waves.

Principle of the method:



(t2).

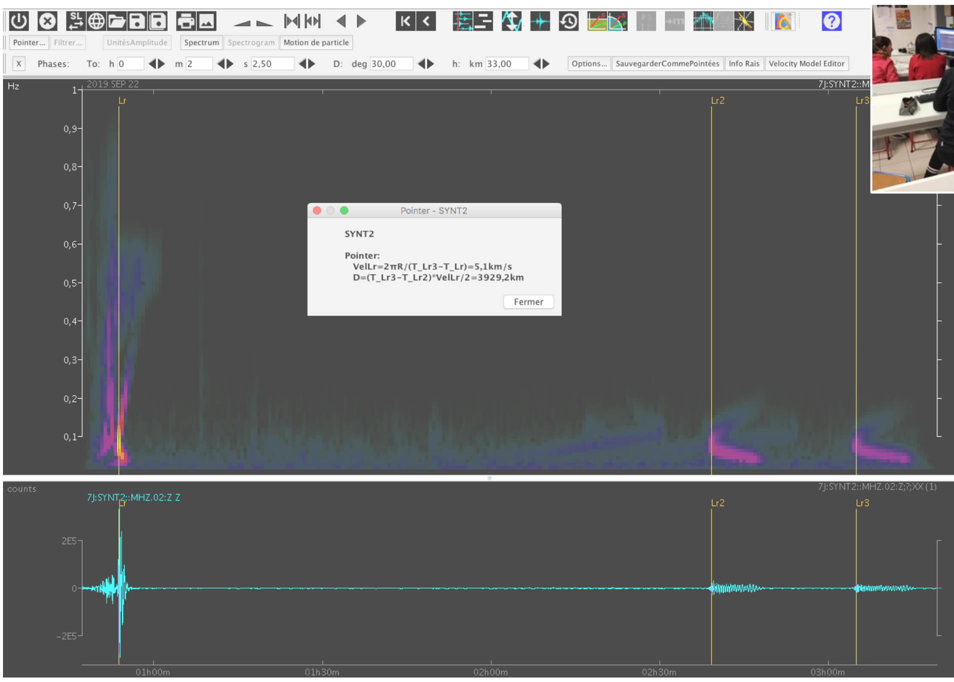


$$SG = \frac{t_3 - t_2}{t_3 - t_1}\pi R_{Planet}$$

$$SG = \underbrace{\frac{t_3 - t_2}{2}}_{t_1 - t_0} \cdot \underbrace{\frac{2\pi R_{Planet}}{t_3 - t_1}}_{V_{Rayleigh}}$$

Detection on blind test records:

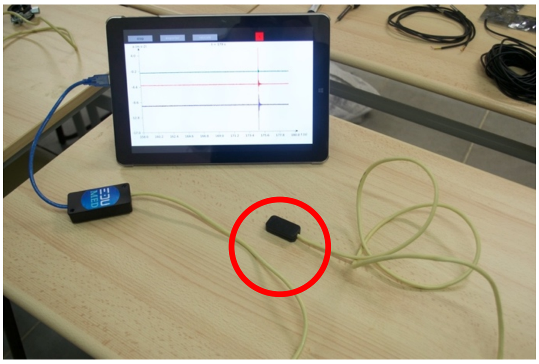
The data is filtered (0,02 Hz < F < 0,05 Hz), then we picked Lr1, Lr2 et Lr3 on Z component.



In this example, 23 minutes for t_3-t_2, and 1h20m for t_2-t_1… thus epicentral distance can be estimated. *(French school in Bucarest, Romania)*

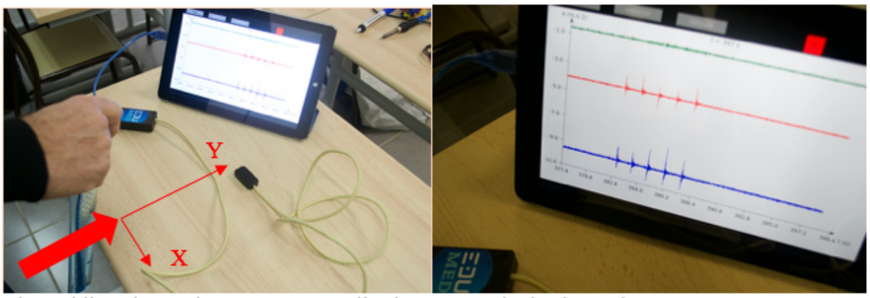
STEP 5: Estimate the azimuth of the seismic event.

Some hands-on experiments can explain easily the interest of a sensor three components. We need an inexpensive accelerometer three components. *(International High school in Valbonne)*

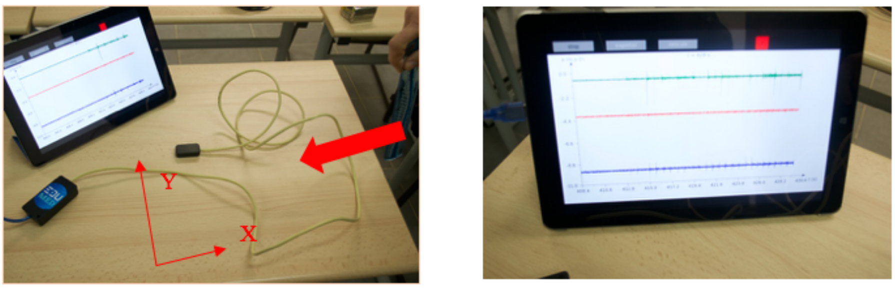


Accelerometer connected by USM port to the computer. Each colour corresponds to a component of the sensor X (horizontal,0°), Y (horizontal, 90°) and Z (vertical).

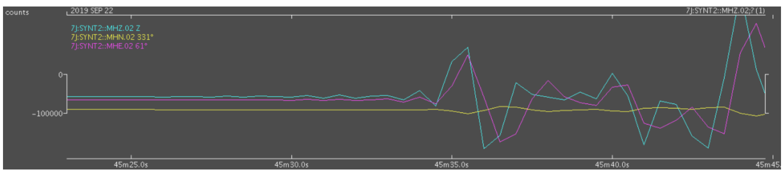
We realize a shock on the table in different points: on an edge, on another edge (horizontal distribution)



The red line shows the strongest amplitudes among the horizontal components



The green line shows the strongest amplitudes among the horizontal components



On this real data, movement is clearly more important on the E-W component.

Conclusion > the observation of the horizontal components on a seismogram can help to determine the direction of the seismic source.
On Mars, the azimuth of the seismic source compared with SEIS will be established by the analysis of the horizontal components. The distance being fixed by R1, R2 and R3.