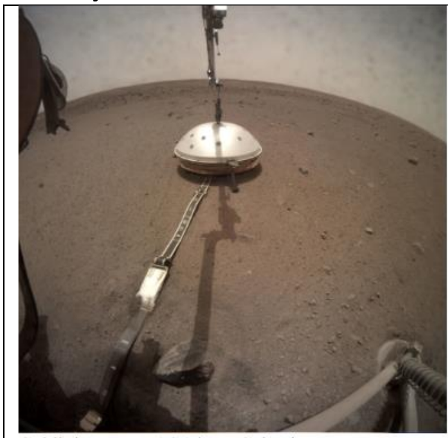
Case study – InSight #1
Effect of the thermal and wind shield on the signal recorded by SEIS

Activity Context:


Crédit image : NASA/JPL-Caltech

On February 2, 2019, the 33rd Julian day, 66 Martian days after landing (sol 66), the seismometer already on the ground receives its protective shield.
The Wind and Thermal Shield helps protect the supersensitive instrument from being shaken by passing winds, which can add "noise" to its data. The dome's aerodynamic shape causes the wind to press it toward the planet's surface, ensuring it won't flip over. A skirt made of chain mail and thermal blankets rings the bottom, allowing it to settle easily over any rocks, though there are few at InSight's location.

An even bigger concern for InSight's seismometer — called the Seismic Experiment for Interior Structure (SEIS) — is temperature change, which can expand and contract metal springs and other parts inside the seismometer. Where InSight landed, temperatures fluctuate by about 170 degrees Fahrenheit (94 degrees Celsius) over the course of a Martian day, or sol.

"Think of the shield as putting a cozy over your food on a table. It keeps SEIS from warming up too much during the day or cooling off too much at night. In general, we want to keep the temperature as steady as possible." said InSight Principal Investigator Bruce Banerdt of NASA's Jet Propulsion Laboratory in Pasadena, California.

On Earth, seismometers are often buried about four feet (1.2 meters) underground in vaults, which helps keep the temperature stable. InSight can't build a vault on Mars, so the mission relies on several measures to protect its seismometer. The shield is the first line of defense.

A second line of defense is SEIS itself, which is specially engineered to correct for wild temperature swings on the Martian surface. The seismometer was built so that as some parts expand and contract, others do so in the opposite direction to partially cancel those effects. Additionally, the instrument is vacuum-sealed in a titanium sphere that insulates its sensitive insides and reduces the influence of temperature.

But even that isn't quite enough. The sphere is enclosed within yet another insulating container — a copper-colored hexagonal box visible during SEIS's deployment. The walls of this box are honeycombed with cells that trap air and keep it from moving. Mars provides an excellent gas for this insulation: Its thin atmosphere is primarily composed of carbon dioxide, which at low pressure is especially slow to conduct heat.

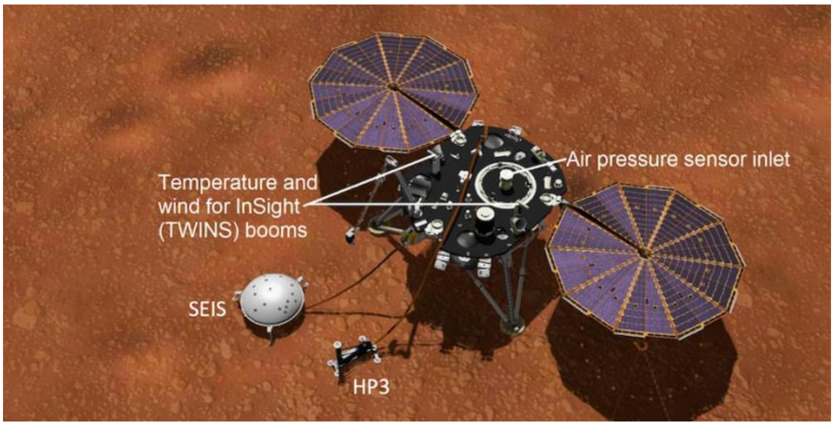
With these three insulating barriers, SEIS is well-protected from thermal "noise" seeping into the data and masking the seismic waves that InSight's team wants to study. Finally, most additional interference from the Martian environment can be detected by InSight's weather sensors, then filtered out by mission scientists.

Hands-on activity goals :
We want to detect, through the data recorded during this period, if the shield has an effect, and what effect on the noise visible on the recordings.

The aim is to recover the signal during the period from January 30, 2019 to February 4, 2019, a 4-day period in the middle of which the shield was successfully deployed. We are interested in the noise recorded by SEIS, but also in the evolution of the external temperature, the temperature under the shield recorded by thermal sensors, We can also be interested in the wind speed and pressure recorded by anemometers and a barometer located on the lander.

Activity step by step :
1/ Data retrieval on the insight-education portal (https://insight.oca.eu) :
Data > Case study > Shield installation
The data are in miniseed (to be read with SeisGram2K) and in csv (to be read with spreadsheet)

Sensors references :
XB.ELYSE :MHV.67 > SEIS seismogram
XB.ELYSE :VKO.33 > outside thermometer on the lander
XB.ELYSE :VKI.03 > thermometer located under the schield
XB.ELYSE :VWS.03 > anemometer located on the lander
XB.ELYSE :VDO.03 > air pressure sensor located on the lander

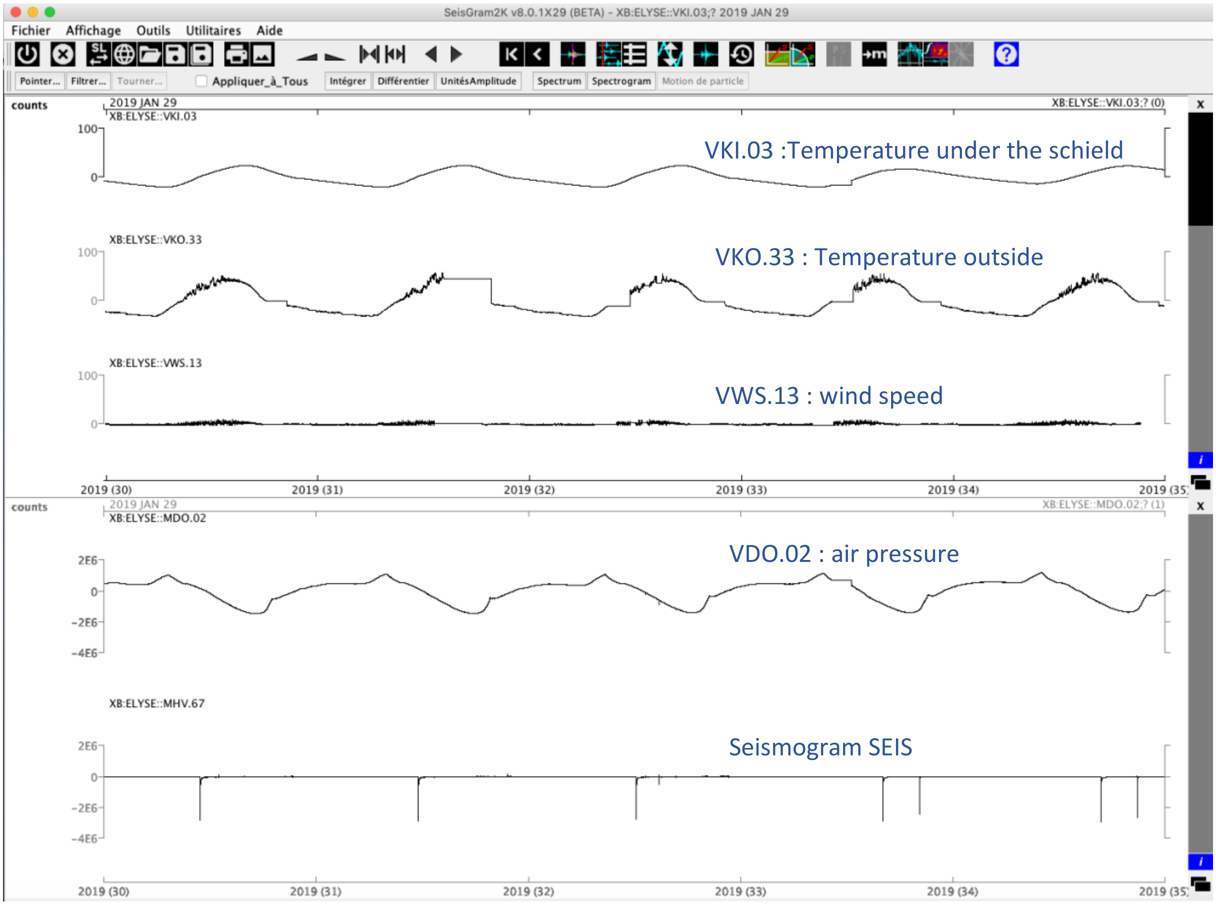


Localisation of the sensors

Dans les deux cas, on cherche à suivre et à comparer l'évolution des divers paramètres sous forme graphique.

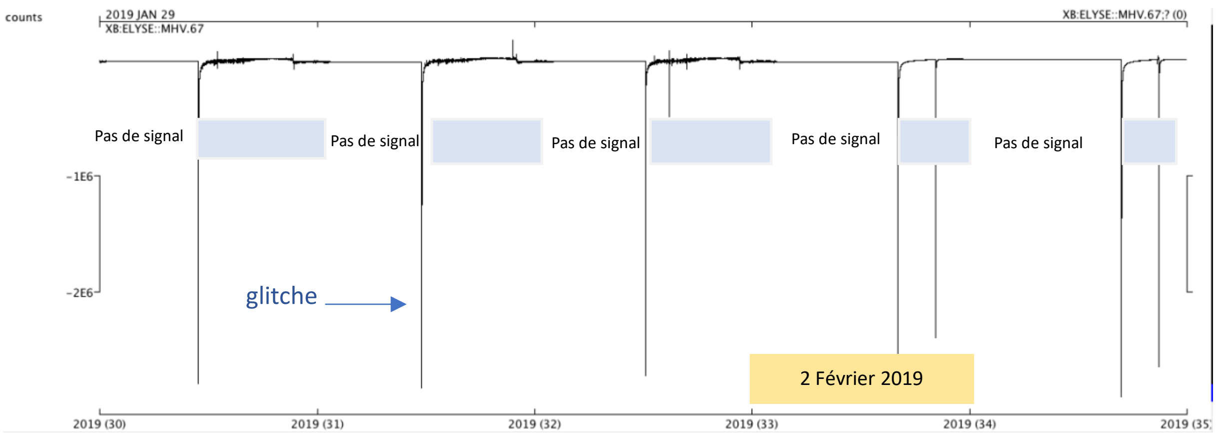
2/ Open data (in miniseed format) with SeisGram2K
Once the data has been downloaded, it can be used with the SeisGram2K software (.mseed) or with a spreadsheet program (.csv)

In both cases, the evolution of the various parameters is monitored and compared in graphical form.



During this period of instrument deployment, there were no continuous SEIS records (MHV.67). A few short signal acquisition sequences were simply performed. The signal is therefore interspersed with periods of time without a signal.

SEIS Seismogram from 30 Jan. to 4 Feb. 2019



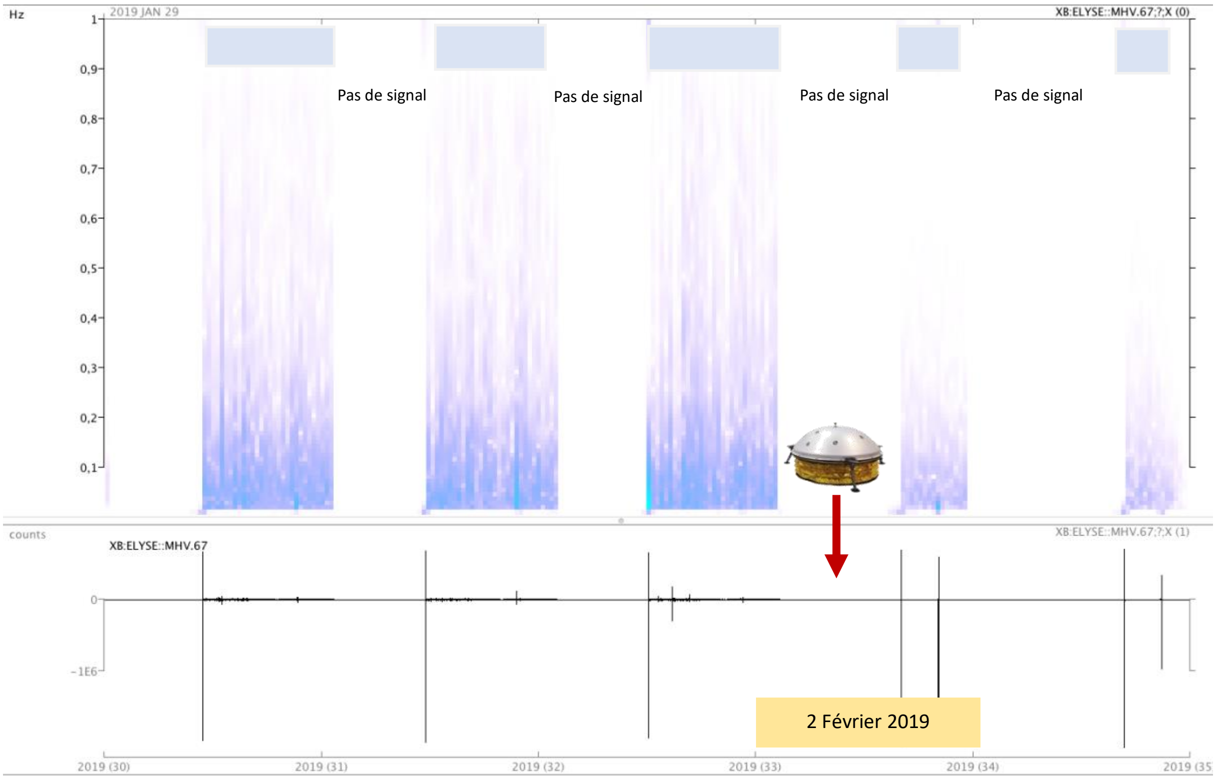
Raw data are also highly parasitized by sudden variations called "glitches" that pollute the recordings a little. We must try to ignore it.

3/ Data analysis

We will focus on the noise recorded on the seismometer. A filter from 0.01Hz to 0.1Hz is recommended on the SEIS signal before studying the signal. This filter (Tools > filter) is applied to the MHV.67 component (the seismogram).

then we ask for the spectrogram of the MHV.67 recording (tools > spectogram).

The result is the following image:



There was a clear visual decrease in noise during February 2, 2019 (Julian Day 33). This decrease can be compared with the installation of the thermal and wind shield on the seismometer by the robotic arm.

We can confirm the effect of the shield on noise reduction since neither the outside temperature (VKO.33), nor the pressure (MDO.02, nor the winds (VWS.13) seem to have changed much during these days.

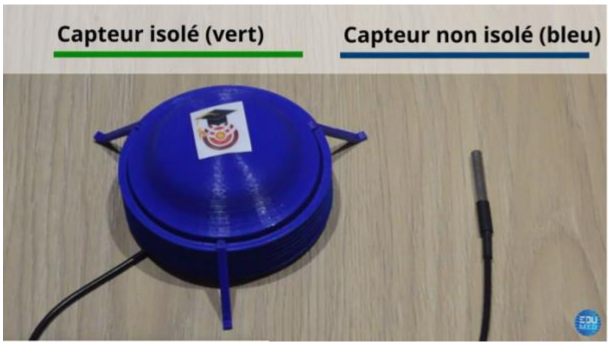
On the other hand, if we compare the outside temperatures (VKO.33) and under the shield (VKI.03), we see a clear effect of the shield on the temperature. Since the two graphs are on the same scale, we can conclude that the shield has an insulating effect on temperature. The temperature is lower, more damped with a slight delay effect on what happens outside.

4/ Modeling the thermal effect of the shield in class

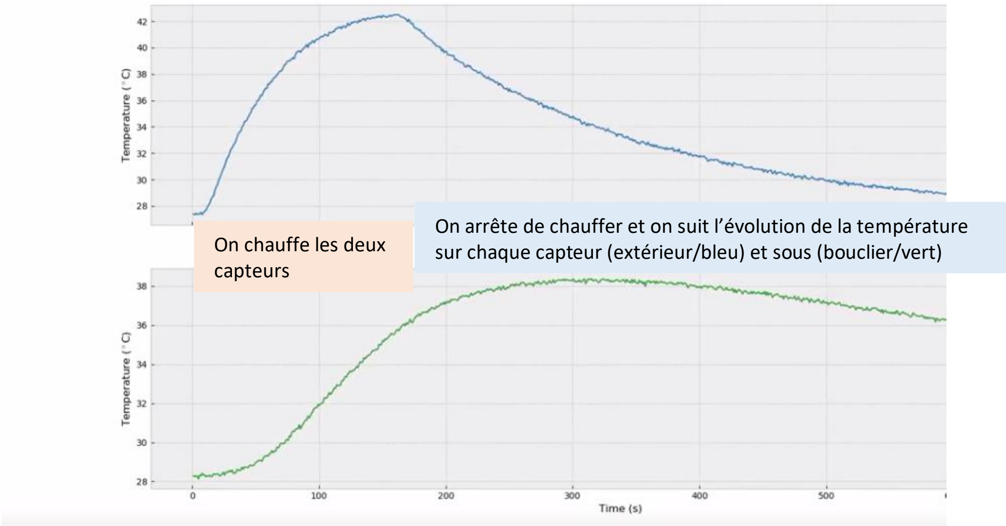
This heat shield effect can simply be reproduced in classroom with sensors. We will use the di-thermo sensor from the InSight kit with the RISSC interface (to download on insight.oca.eu > topic sensor).

The experiment consists of monitoring the temperature evolution on two thermometers, one placed outside and the other under an insulating shield (insulation made of plastic with bubbles).

The experience and material is described online:
https://insight.oca.eu/fr/hands-on-pratiques/topic-sensor/512-insight-sensors-kit-students



The two thermal sensors are heated with a hair dryer... and the temperature evolution for each sensor is monitored over time.



Evolution for temperature of the two sensors