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Designing a new post-hole seismological station on Antarctica inlandsis (Concordia station)

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ABSTRACT

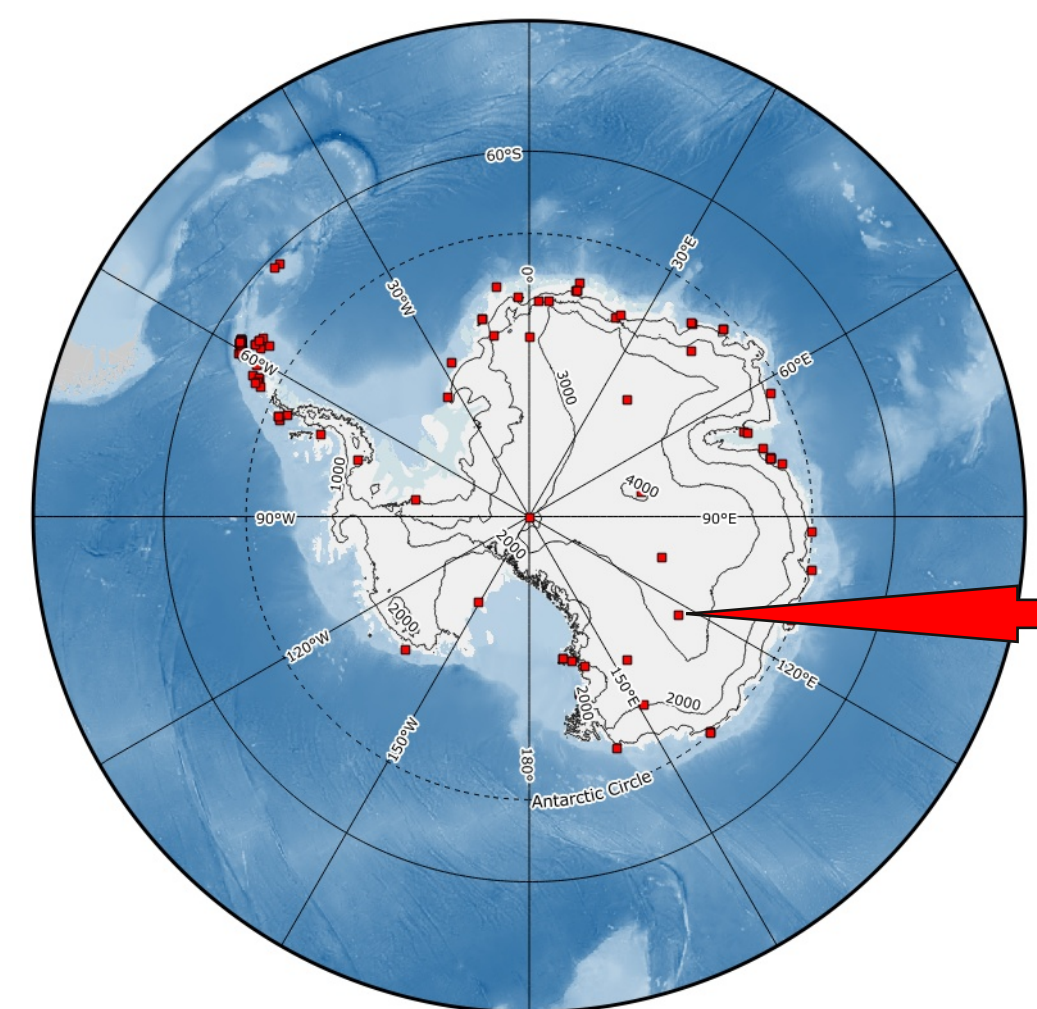
Concordia (75°S 123°E) is a scientific base operated by French and Italian polar institutes IPEV (Institut Paul-Emile Victor) and PNRA (Programma Nazionale di Ricerche in Antartide, and is located on the inlandsis of the East Antarctica plateau.

It hosts a seismological station CCD which has provided observatory quality data since the year 2000, has been integrated into the Geoscope network since 2008 and whose data are now available in real-time from IRIS. The current seismic vault is located 800m from Concordia base, as far away as is deemed logistically possible by IPEV, at a depth of 12m. The vault is thermally very stable, but given the close distance to the base, suffers from increased diurnal noise (up to 40 dB) at frequencies above 1Hz, especially in the summer season. Anthropogenic noise is trapped in the firn (snow) layer, which forms an 100-110m thick waveguide, and is picked up very easily in the seismic vault. The vault is made from steel containers buried vertically in the snow. The hydrostatic pressure of the snow is deforming them: we see container cracking events on the seismograms, and also visual evidence of container deformation inside the vault. In the near future, this deformation will create a security problem.

We have decided to progressively abandon our current vault, and construct a new post-hole seismological installation nearby. We plan to drill to 130m depth, which would place us below the firn layer waveguide and also below the ice pinch-out depth. To be able to run the station for several years and change or service the instrumentation if required, we need to keep the hole open, to avoid any hydrostatic movement, and to maintain good coupling between the sensor and the surrounding hard ice. To achieve these goals, we shall install a casing in the firn layer and then drill a few meters more without casing in hard ice. After installing the instrument, we shall then fill the whole hole with a drilling fluid whose density is similar to that of ice.

The drilling will be carried out by the French drilling facility C2FN (Centre de Carottage et de Forage National) of the CNRS (Centre National de la Recherche Scientifique), and the is planned for the 2018-2019 summer season.

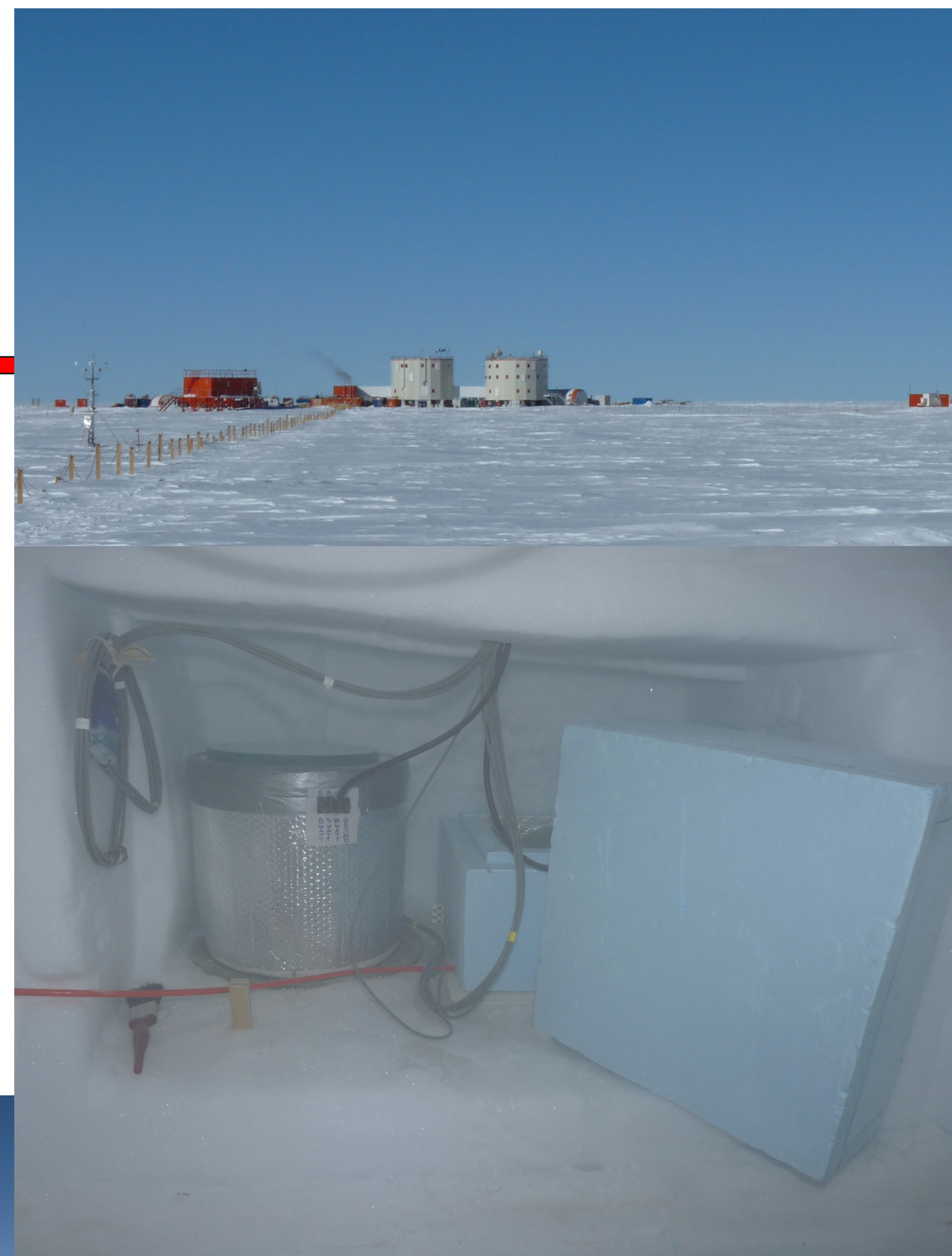
CURRENT SITUATION



Upper left: Location of Concordia on East Antarctica Inlandsis (-75°S, 123°E, 3200m)

Upper right: Overview of Concordia station from the instrumentation shelter, 800m far away.

Center: Current installation of STS2 seismometers in 12m deep niche. The temperature is very stable at -54°C.



Bottom left: Current instrumentation shelter. This shelter is nowadays completely snowy. The cave is accessible through a hatch into the shelter and a 45m long gallery 1m below the surface. Then, a ladder allows going down into the cave.

PLANNED SENSOR INSTALLATION

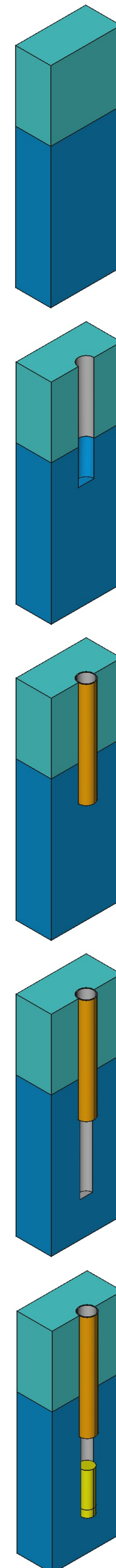


Figure 1: The firn (clear blue) is about 110m deep. It acts as a waveguide for anthropic noise (Anderson et al., 2003). Our goal is therefore an installation within the hard ice below (dark blue).

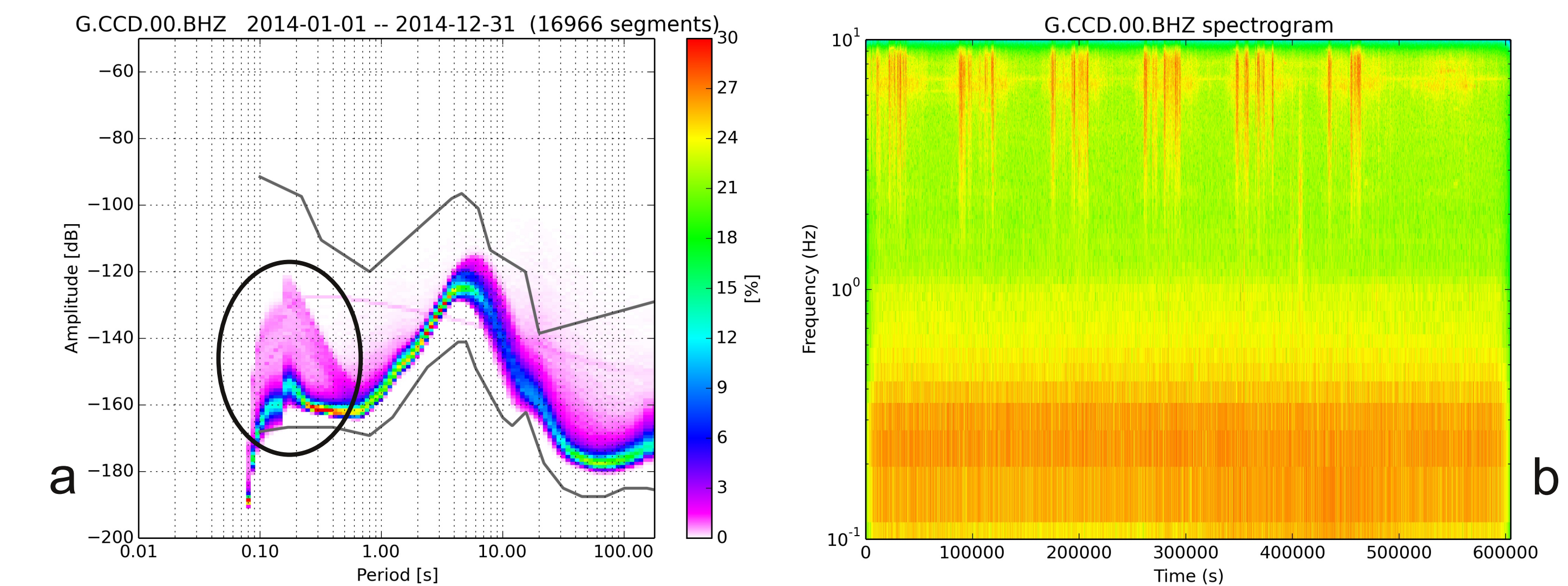
Figure 2: The first step will be to drill at a depth a few meters below the interface between firn and ice. We therefore chose 130m. (D=250 mm)

Figure 3: The casing is installed, avoiding the hole closing. It's made in HDPE tubes (D=225 mm, d=204,5mm)

Figure 4: An other drill is performed only one meter below the casing, directly in the hard ice. The completion of drilling and installation of casing will be performed by the french drilling facility C2FN.

Figure 5: The sensor is classically installed into the hard ice, without any contact with the casing. The part of the hole without casing will naturally close but in a much longer time than the firn, as it takes several years into the hard ice. Eventually, we plan to fill with silicone based oil as drilling fluid.

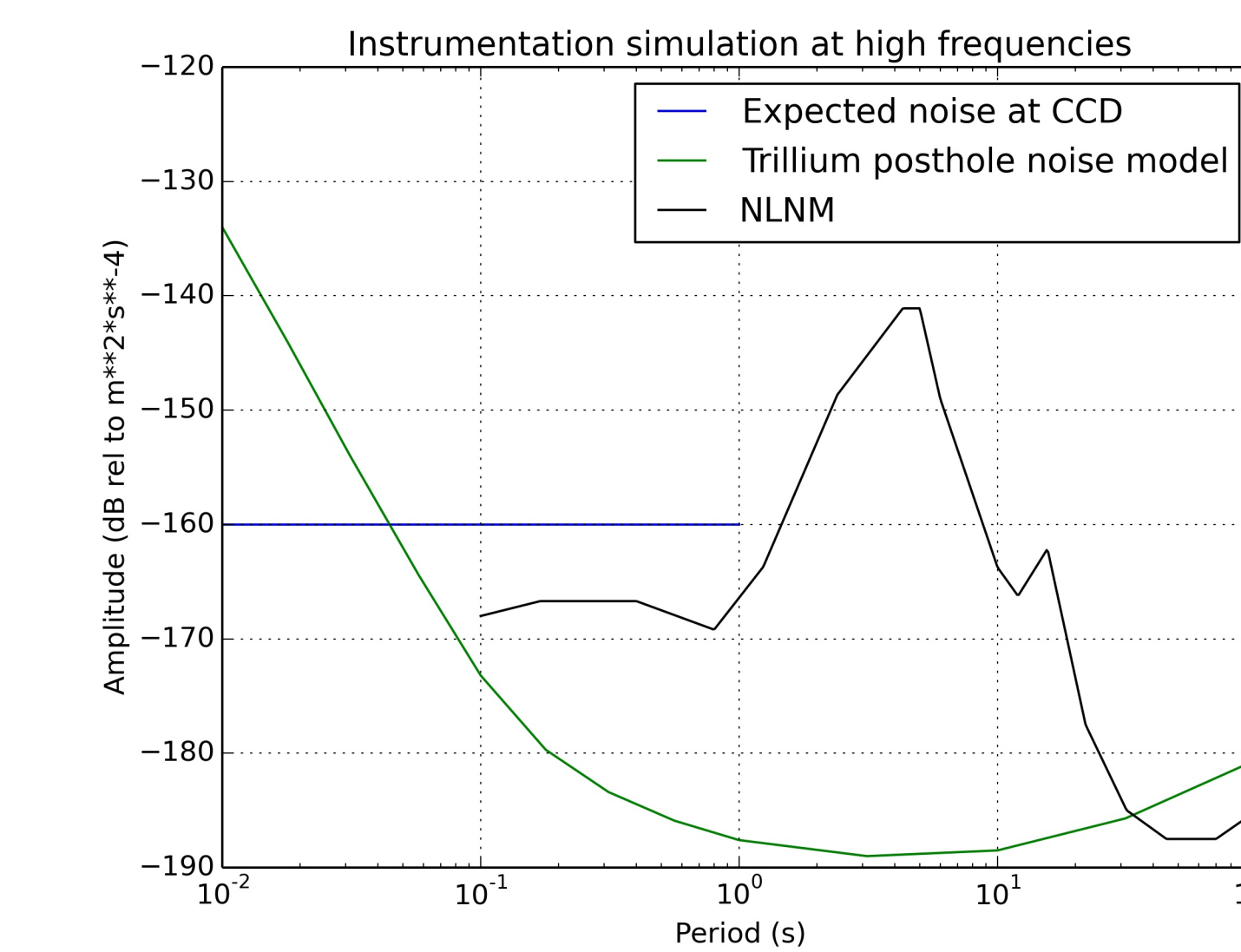
NOISE ANALYSIS AND EXPECTED GAIN



Probability of Power Spectral Density (PPSD) over the year 2014 (a) and typical week spectrogram (b).

The noise level rises up to 40db in range 5-10Hz, which seems to prove the station is very sensitive to anthropic noise. It rises up during working hours, specially in summer season. After new installation, we expect the station will reach its natural level, which is remarkably low (10 dB only above NLNM). We know such an installation allowed South Pole station to get a high-frequencies noise level below the noise model (Anderson et al., 2003).

INSTRUMENTATION CONSIDERATIONS



PERSPECTIVES

A new shelter on piloti (to limit snow accumulation) will be installed during 2017-2018 summer season, by IPEV technical staff.

The drilling and seismometer installation will be realized during 2018-2019 summer season, by C2FN staff. For the next following seasons, we plan to buy suitable instrumentation and perform several calibration tests on surface, in order to check how it supports extreme conditions and its instrumental noise at $f > 10$ Hz. We also will buy equipments needed to perform the installation (casing, tripod, etc...) as logistics in Antarctica must be planned a long time ahead.

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