

Acoustics'08 Paris



[[Lay Language Paper Index](#) | [Press Room](#)]

Listening to Antarctic Ice Breaking from Australia

By Alexander Gavrilov and Binghui Li
Centre for Marine Science and Technology
Curtin University of Technology
A.Gavrilov@curtin.edu.au

Paper **1pAOa3. Long-term variations of ice breaking noise in Antarctica .**

The rate of ice break up, or ice calving, from the Antarctic ice shelves is one of the major indicators of global climate change. The events of iceberg calving observed for the past two decades have been extraordinary, and have led to dramatic changes in the Antarctic ice sheet. However, it is still a subject of serious discussions whether the calving rate is staying within natural bounds or steadily increasing. While calving of massive pieces of ice is well observed from satellites, numerous ice shelf breaks of smaller volume are not monitored and statistically analysed. Moreover, the calving events are preceded long before by ice cracking, which is not remotely observable by ordinary means. To predict the further disintegration of the Antarctic ice sheet, gathering statistics of ice breaking intensity all around the Antarctic shelf is needed.

Ice cracking and breaking events make loud noises, which spread in ice to the water in the surrounding ocean. Seismo-acoustic sensors placed on the ice shelf are capable of recording this noise in ice, but can collect data only from the nearby area, because sound attenuates rapidly in an ice body. On the other hand, once the sound signal from ice breaking gets into the adjoining water, it can propagate in the ocean over thousands of kilometres with little loss of energy, so that a single underwater sea-noise recording system located far away from the Antarctic coast can listen to a large sector of the Antarctic ice shelf. Such systems have already been deployed in the ocean as part of the International Monitoring System of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). There are three CTBT underwater listening stations installed in different parts of the Indian Ocean (Figure 1). Each station consists of three receivers placed in the middle of the natural ocean acoustic channel, where underwater sound propagates over large distances without interaction with the sea surface and the seafloor. The receivers are spaced horizontally to form a triangular array about 2 km wide, which allows us to determine the direction to sources of noise in the ocean. An intersection of bearings from two remote stations gives the location of a noise source. Each station is cabled to the shore, so sea noise data can be processed in real time.

An analysis of 7-year long recordings of sea noise made at the CTBT underwater station off Cape Leeuwin in Western Australia has shown that Antarctica is the major source of low-frequency noise in the Southern Ocean and southern parts of the Indian Ocean (Figure 2). Two different kinds of signals arriving at the Cape Leeuwin station from Eastern Antarctica can generally be distinguished. The most amazing of

them are iceberg songs, which are very-low-frequency, from about 3 Hz to 10 Hz multi-harmonic signals lasting sometimes for several hours and which are supposed to be produced by vibrations of the iceberg plate after collision with the seafloor, ice shelf or another iceberg (*listen to attached [Sound File 1](#) with an iceberg song played back 20 times faster to bring it into the frequency range of human hearing*). The second type of Antarctic noise signal comprises short-term sound pulses, which are the main focus of this study, because they are believed to be emitted by ice cracking and breaking events. More than a hundred of such signals are detected weekly at the Cape Leeuwin station. To examine the origin of these signals, an autonomous sea noise recorder was installed on the seafloor of the Antarctic continental shelf for a year, to make recordings concurrently with the CTBT station off Australia. The sound signals from a series of ice cracking and breaking events recorded on the Antarctic noise logger are shown in Figure 3 (*and stored in [Sound File 2](#) also played back 20 times faster than the real signal*). This series of signals recorded at Cape Leeuwin looks similar in general, but the waveform of each individual signal has dramatically changed after travelling over 3500 km. Only low-frequency components from about 5 Hz to 30 Hz reach Australia. Moreover, because of peculiar environmental conditions in the polar seas, where the speed of sound is minimum at the sea surface and grows steadily with depth, the lower frequency components travel faster than the higher frequency ones, which makes the recorded signals sound like an up-tone whistle when played back 20 times faster ([Sound File 3](#)).

The main purpose of this research project is to investigate whether it is possible to detect and monitor significant changes in the disintegration rate of the Antarctic ice shelf due to global climate change by counting the occurrence frequency of ice breaking signals detected at remote underwater listening stations. The long-term variation of the number of ice events detected weekly at the Cape Leeuwin CTBT station during seven years of observation is shown in Figure 4 on the top panel. After filtering short-term fluctuations, it becomes evident that the rate of ice events contains a strong seasonal component, which is also demonstrated by the spectrum of this data series shown on the bottom panel. This result proves the capability of underwater acoustics to remotely monitor long-term variations of ice breaking intensity in Antarctica. On the other hand, seven years of observation have not revealed any significant climatic trend, which could probably be regarded as a good news.

Another important finding is that certain parts of the Eastern Antarctica ice shelf observed from Cape Leeuwin are much noisier than other parts, which is demonstrated in Figure 5 showing the total number of ice events detected at the CTBT station in all directions to the Eastern Antarctica coast. Some of the noisiest shelf areas are undoubtedly associated with the glaciers, which are known to be active sources of newly calved icebergs, such as the Dibble and Dalton Ice Tongues. On the other hand, the largest number of ice signals arrive from the continental shelf north of Law Dome, which is a very thick coastal glacier, located east of the Australian polar station Casey, and which does not stretch into the sea with an ice tongue. More research is needed including in-situ observation to explain the noisiness of this part of the Antarctic shelf.

This research project is continuing, however, it is already possible to conclude that remote underwater acoustic observation is a useful and cost-effective approach to monitor ice cracking and breaking processes in Antarctica and is an efficient supplement to satellite remote sensing and in-situ observations aimed at climate change studies in Antarctica.

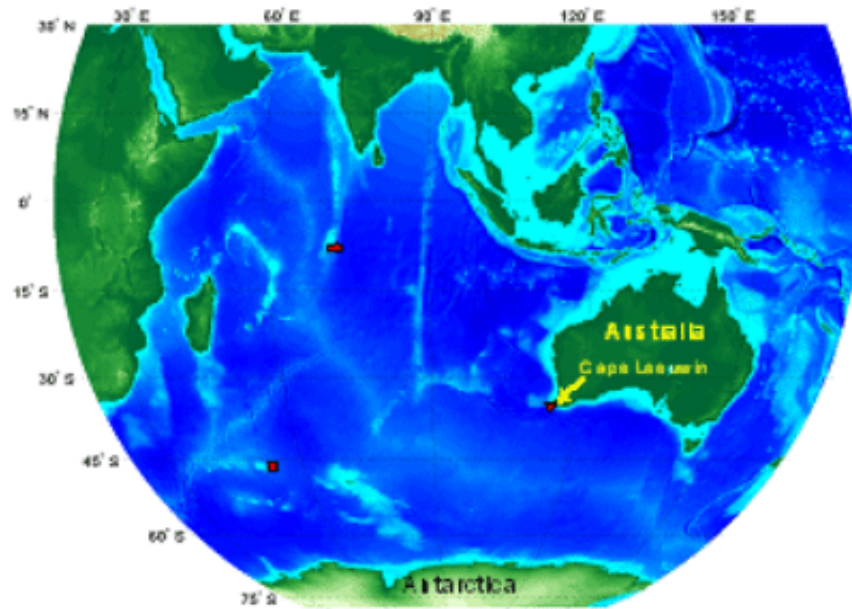


Figure 1: Location of three CTBT underwater listening stations in the Indian Ocean

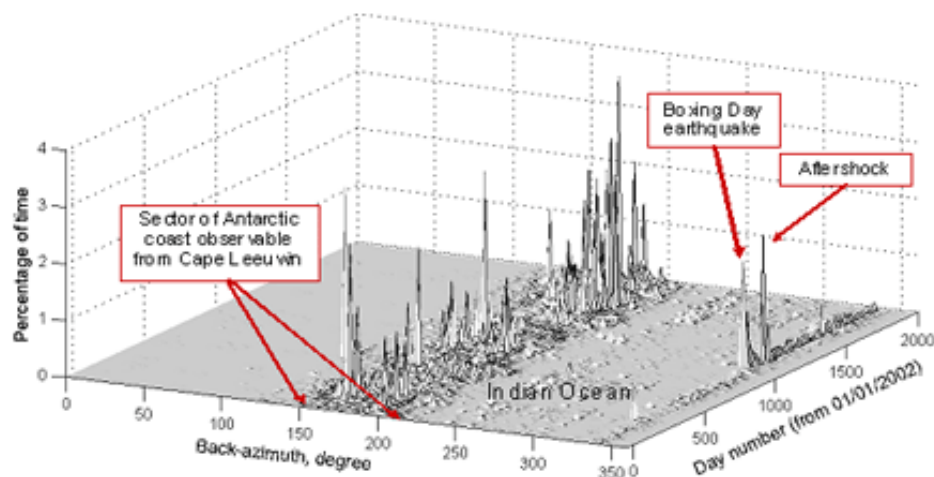


Figure 2: Percentage of time when low-frequency noise signals were observed in different directions from the Cape Leeuwin station in 2002 – 2007. It is obvious that the majority of sound signals arrive from Antarctica. Note also that the Sumatra fracture zone visible from Cape Leeuwin at about 340 ° has been permanently making noise since the Boxing Day earthquake.

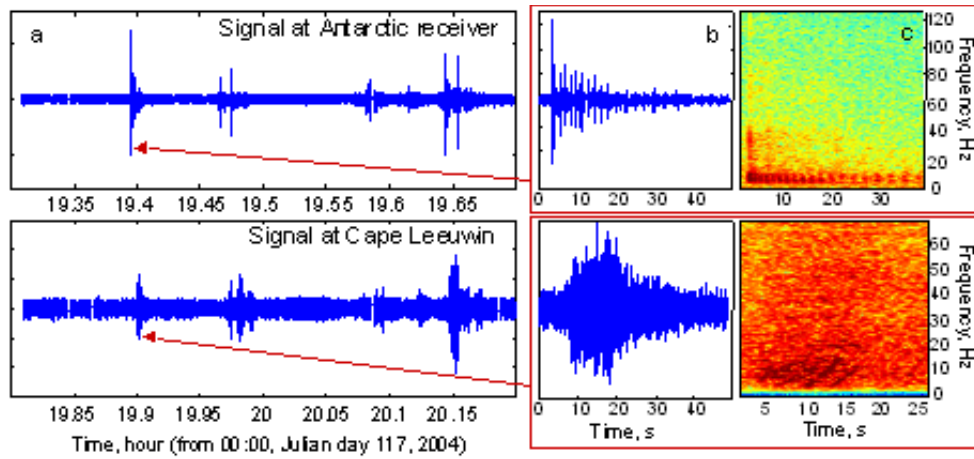


Figure 3: (a) Signals from the same series of transient events recorded on the Antarctic sea noise logger (top) and at the Cape Leeuwin station (bottom). Waveforms (b) and spectrograms (c) of the first signal in the series of events at the logger (top) and Cape Leeuwin (bottom).

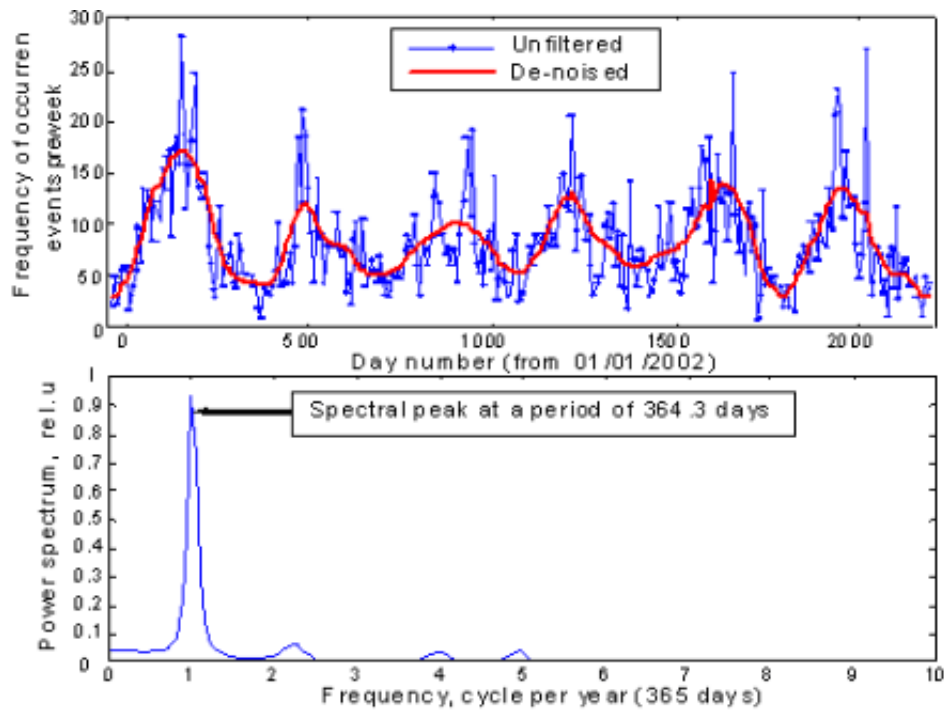


Figure 4: (top panel) Temporal variations of the number of signals from Antarctic ice events detected weekly at the Cape Leeuwin underwater listening station shown before (blue line) and after (red line) de-noising by low-pass filtration; (bottom panel) Power spectrum of unfiltered variations demonstrating the presence of a strong seasonal cycle.

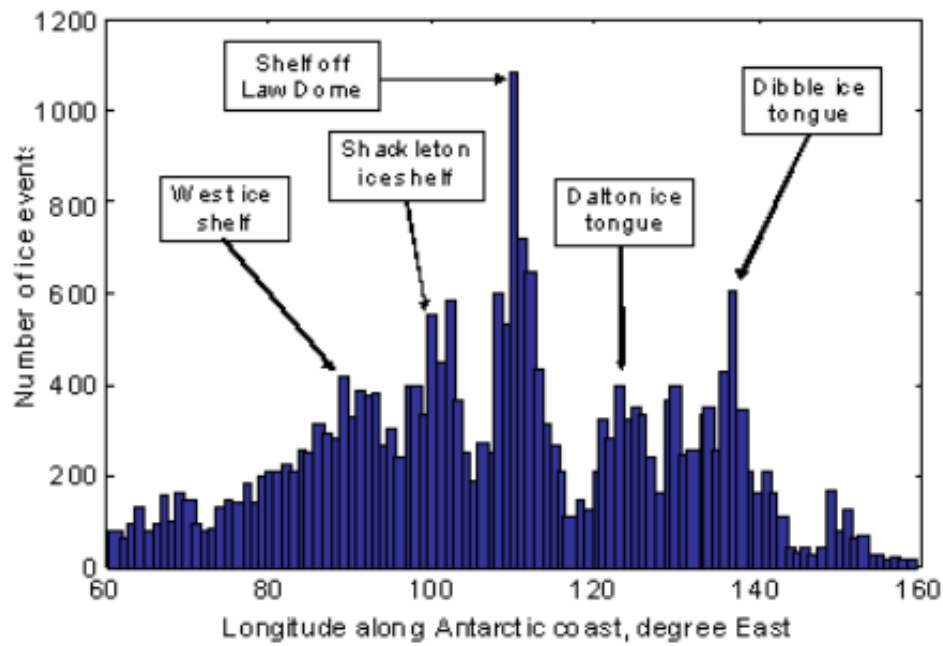


Figure 5: Histogram of the total number of ice events located from the Cape Leeuwin station in different directions to the Eastern Antarctica shelf in 2002-2007.

[[Lay Language Paper Index](#) | [Press Room](#)]