Verification highlights

Building monitoring facilities in the coldest, driest and windiest continent on Earth: Antarctica

by Denise Brettschneider

JOURNEY THROUGH THE ICE TO PALMER STATION, ANTARCTICA.

"It was the darkness that did it. I don't believe minus seventy temperatures would be bad in daylight, not comparatively bad, when you could see where you were going..." In *The Worst Journey in the World: A Tale of Loss and Courage in Antarctica*, Apsley Cherry-Garrard describes the last expedition to the Antarctic by the explorer, Robert Scott, and his team in 1910.

Total darkness for six months a year

The long periods of constant darkness during the winter contrast starkly with the summer months in Antarctica, when it is light for almost 24 hours a day. Renowned for having the harshest and most extreme environment on earth, the world's lowest temperature of minus 89 degrees Celsius was recorded in 1983 at the Russian (former Soviet) Vostok research station in the centre of East Antarctica. The mean annual temperature of the interior is minus 37 degrees Celsius. And although Antarctica has more fresh water than any other continent, it also receives the least precipitation, with only slightly more rainfall on average than the Sahara Desert.

Its reputation as the windiest and least hospitable continent on Earth is well-deserved. Strong katabatic winds caused by the drainage of cold air down the steep slopes of the ice sheet from the higher interior of the continent, have been measured at over 250 km/h. These winds sometimes ravage the continent for several days. Blizzards are another typical Antarctic phenomenon which can last for a week at a time, reducing visibility to a few feet. Whiteouts, in which there are no shadows or contrasts between objects causing a loss of depth perception, are also commonplace. Explorers have been known to get lost and freeze to death while only metres away from their tents.

Unsurprisingly, Antarctica has never had an indigenous population of humans. Yet its importance as a natural reserve is recognized internationally. Approximately 30 nations, all signatory to the 1961 Antarctic Treaty, send personnel every year to perform seasonal and year-round research on the continent and in its surrounding oceans. The population of scientists varies from approximately 4,000 in summer to 1,000 in winter.

Hostile environment and logistical challenges

In order to provide uniform coverage of the globe, the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) has already established several of its monitoring facilities in remote areas that are difficult to access. These facilities are part of the International Monitoring System (IMS) and include a number of stations

in Antarctica: eight seismic, infrasound and radionuclide stations have already been certified by the CTBTO as meeting defined requirements and specifications and another five stations are planned.

The IMS comprises a global network of stations and laboratories that monitor the Earth for evidence of a nuclear explosion in compliance with the provisions of the Comprehensive Nuclear-Test-Ban Treaty (CTBT), which bans all nuclear explosions on the planet.

As well as contending with an extremely hostile environment when constructing stations in Antarctica, the CTBTO is also confronted with logistical and engineering challenges: the transportation of installation equipment needs to be meticulously planned and coordinated and stations must be specially designed in order to withstand polar conditions.

There are no developed ports on the continent and only a few locations have a basic wharf facility. Most coastal stations have offshore anchorages, and supplies are transferred by boats, barges and helicopters. Satellite communication is extremely difficult due to the high latitudes — Antarctica is the highest continent in the world, with an average height of 2,400 m above sea level ––and it is only possible from certain research facilities.

DIGGING OUT THE WIND NOISE REDUCING PIPE ARRAY AND EQUIPMENT VAULTS AT IS55.
PHOTO COURTESY OF DUNCAN MARRIOTT, GEOPHYSICAL INSTITUTE, UNIVERSITY OF ALASKA, FAIRBANKS.

Buried in snow

Windless Bight is a desolate ice plain devoid of any vegetation, where temperatures plummet to below minus 40 degrees Celsius. Infrasound station IS55 is part of the IMS and uses very sensitive microbarometers to detect low frequency sound waves which are inaudible to humans. These waves can travel thousands of kilometres and are produced by a variety of natural and man-made sources, including nuclear explosions. The latter events have an identifiable signature which distinguishes them from other types of infrasound sources.

SEA ICE AND STORMS CAN SLOW THE JOURNEY DOWN.

Windless Bight was chosen as a location since, as the name implies, there are virtually no surface winds there in contrast to the rest of Antarctica. In addition, the infrastructure of the Antarctic base that already existed provided crucial support for the establishment of the station.

The site is powered by a hybrid diesel/solar power supply to ensure continuous operations and uses the United States National Science Foundation’s (NSF) communication system (which funds and manages the United States Antarctic Programme) to transmit data to Denver, Colorado. The data are then transmitted via the CTBT’s Global Communications Infrastructure (GCI) to the International Data Centre (IDC) in Vienna, where they are processed to detect, locate and analyse events. The raw data and analyzed data, so-called IDC products, are transmitted to Member States.

SHIPPING SUPPLIES AND PERSONNEL TO PALMER STATION
PHOTO COURTESY OF NSF/USAP BY DAVID BRESNAHAN, NATIONAL SCIENCE FOUNDATION.

Windless Bight receives about 1.5 metres of snow accumulation every year. The equipment vaults where the microbarometers are located must, therefore, be dug out every season and replaced on top of the snow. Infrasound waves can generally penetrate the snow for several centimetres with little attenuation (in the presence of attenuation, the signal becomes weaker over distance, i.e. with smaller amplitudes), but when the layer of snow becomes too thick, the risk of attenuation becomes higher. It is therefore also necessary to dig the wind noise reducing system, which is connected to the equipment vaults, out of the snow every year during the annual maintenance of the station.

Communicating with the southernmost point on the surface of the Earth

While the Earth's Polar Regions offer unique scientific research possibilities, their isolation and extreme climates render such opportunities extremely challenging. The North and South Poles are the only places on Earth that cannot see geosynchronous communication satellites because of the distance from the Equator.

In conjunction with the United States Geological Survey (USGS), the IMS operates an auxiliary seismic station at the South Pole – AS114. This station provides data on seismic events to the IDC to supplement information gathered by primary seismic stations. By the time the IMS has been completed, a total of 120 auxiliary seismic stations will have been certified by the CTBTO.

The issue of no satellite coverage for up to 12 hours a day needed to be addressed and the gap has now been filled by satellites belonging to the Iridium network. The Iridium network is a commercial constellation of 66 communication satellites that circle the Earth on pole-to-pole orbits at a height of 780 kilometres. The Iridium network is unique in that it covers the whole Earth, providing communication coverage at the poles from where other satellites are not visible. The CTBTO has collaborated closely with the USGS to develop this service, which has been heralded as a breakthrough in satellite communication technology. Using this network and with the support and assistance of USGS and NSF, AS114 has been able to transmit important seismic data from the South Pole via Denver to the IDC on a 24-hour basis without interruptions since February 2007.

To facilitate operations, the IMS has provided AS114 with a special station interface computer so that it can respond to automatic data requests from the IDC. Despite the remoteness of the station and the climatic extremes, AS114 has now been fully integrated into the IMS.

1,400 km sea voyage from Punta Arenas to Anvers Island

Radionuclide monitoring station RN73 is located at the United States owned Palmer Station on a protected harbour on the south western coast of Anvers Island off the Antarctica Peninsula. The station has been

CTBTO'S COMMUNICATION OFFICER OUTSIDE AS114 AT THE SOUTH POLE.

RE-ATTACHING WIND NOISE REDUCTION PIPE ARRAY TO VAULT AT IS55.
PHOTO COURTESY OF DUNCAN MARRIOTT, GEOPHYSICAL INSTITUTE, UNIVERSITY OF ALASKA, FAIRBANKS.

built on solid rock and consists of two major buildings and three smaller ones, one of which accommodates station RN73, as well as two large fuel tanks, a helicopter pad, and a dock. Palmer Station can occupy a maximum of 46 people and is staffed all year round, although the population during the winter months is usually about 15.

Delivering supplies to stations in Antarctica requires careful planning and access to specially constructed vessels. The Research Vessel R/V Laurence M. Gould, a ship with an ice-strengthened hull designed for year-round polar operations, supports research in the Antarctic Peninsula region by transporting supplies, researchers and staff between Punta Arenas in Chile and Palmer Station. The 1,400 km journey takes approximately four days, although sea ice and storms can slow the journey down.

RN73 is part of a network of 80 radionuclide monitoring stations that enables the continuous worldwide observation of aerosol samples of solid radionuclides or radionuclide particles. The station contains a Radionuclide Aerosol Sampler Analyser (RASA), which is a fully integrated and automatic system for monitoring airborne radionuclides. The meteorological system is located on a mast on the roof of the building and is connected to the RASA computer. It includes sensors to measure temperature, barometric pressure, humidity, precipitation, wind speed and wind velocity. The RASA software controls the station equipment and gathers information about the airflow, air sampler temperature and pressure etc. and meteorological data.

As with IS55 and AS114, this information is sent through the NSF's communication system from Palmer Station to Denver and from there to the IDC via the GCI. RN73 has been transmitting data via the United States to the IDC every two hours since November 2005.

The radionuclide station is operated by General Dynamics - Advance Information Systems (GD-AIS), with the local support of the NSF. The station is unmanned most of the time with a local operator visiting the station at least once every two weeks to perform a physical security and operational check on the RASA.

Complete global coverage

The extreme geographical and climatic conditions in Antarctica mean that installing and maintaining monitoring stations is a costly and complicated exercise. By establishing stations in such places, the IMS network provides complete global coverage, thereby acting as a powerful deterrent to potential violators. ■

Denise Brettschneider is working as a writer and editor with the CTBTO's Public Information section. She has a number of years of editorial experience working for organizations in Kenya including the United Nations Educational, Scientific and Cultural Organization. ■