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The University of Münster Airborne Ice Radar (UMAIR): Instrumentation and first results of temperate and polythermal glaciers

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A helicopter borne 30 MHz ice radar has been developed and manufactured at the Institute for Geophysics, University of Münster, Germany. The UMAIR system may operate from any helicopter capable of carrying a sling load of 300 kg which makes it a versatile instrument which can be used in many glaciated regions within helicopter range.

The antenna comprises two shielded broadband dipoles with transmitting and receiving electronics. This construction is attached to a 20 m long heavy duty rope and is connected to the control unit inside the helicopter via thin fibre optic cables. Stabilizers and flaps are keeping the antenna horizontally and in flight direction at an air speed of 30 to 40 knots.
Antenna position is recorded by a dual frequency GPS receiver. Antenna altitude above ground is measured by a laser altimeter which has also an extra display for the helicopter pilot helping to maintain an altitude of about 40 m.
The impulse is a one-and a half cycle wavelet with a dominating frequency of about 30 MHz. Hence, the antenna footprint at the surface in air has a diameter of about 30 m, at 100 m depth in the ice 40 m, and at 1000 m depth 110 m. Vertical resolution of adjacent layers is 6 m, vertical accuracy for a single plane reflector about 1 m.

First tests on Tyndall and Grey Glaciers (Southern Patagonian Ice Field, Chile) showed that the instrument is capable of penetrating more than 800 m of temperate ice in spite its crevassed surface and occasional melt water ponds. A lot of scattering both at the bedrock and the surface helps to overcome the limitations of total reflection which would occur with ideally smooth surfaces for bedrock dips of more than 17°. The same applies for a number of Swiss glaciers with steep beds. Seismic data processing including migration has to be used for the reconstruction of the bedrock topography which is measured preferably on transverse profiles.
Besides the sounding of ice thickness the system is capable to reveal a number of internal features such as layers in firn and ice including the water table, water inclusions and ducts in parts of temperate ice, absence of scattering and lower absorption in the case of cold ice.

The UMAIR system is also a tool for near-surface geophysics: Penetration depth of helicopter borne GPR measurements over glacial sediments in Northern Germany was up to 30 m, the thickness of a salt deposit in Northern Chile was measured down to 80 m depth.