ARCA WP2 - Greenland ice cap and outlet glaciers evolution:

From South to North: the contribution of RES exploration technique

Principal results of INGV Radio Glaciology group

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Abstract

Radio Echo Sounding (RES) system is an active remote-sensing instrument that uses the electromagnetic wave penetration into the ice to obtain information on the level of the bedrock, the ice thickness and inhomogeneity, i.e. the internal layering of glaciers and subglacial lake exploration (Fig. 1).

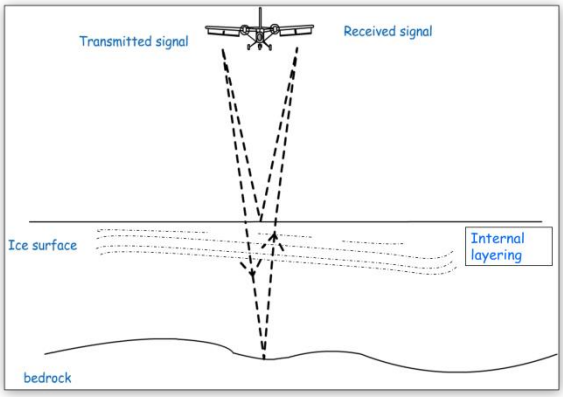

Figure 1 – Sketch of airborne Radio Echo Sounding ice measurements

From 1995 the INGV develop its own airborne radio echo sounding system (Fig. 2) which is continuously upgraded. During the 1995, 1997, 1999, 2001 and 2003 Italian Antarctic Expeditions, the RES system was put on an aircraft flying 1000 feet above the ice surface with two folded dipole antennas mounted beneath the aircraft wings, one for transmission and the other for receiving echo pulses. The maximum penetration depth (range) in the ice was about 5.3 km.

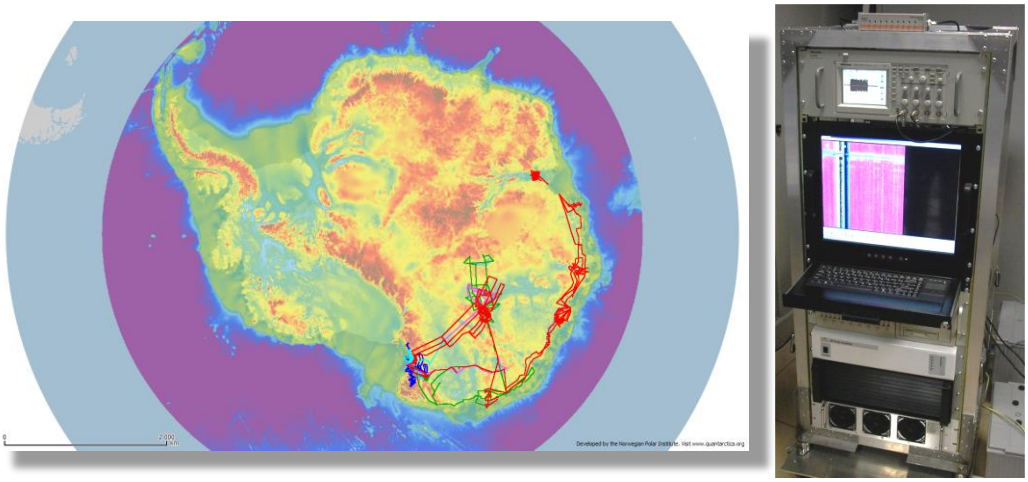

Figure 2 – On left, I-RES measure coverage from 1995; on right an image of the INGV "GlacioRadar"

From the 1995 to 2014 Italian Antarctic Expeditions, extensive airborne radar surveys were carried out over the East Antarctic Ice Sheet (EAIS) covering more than 36.000 km of flight lines (Fig. 2). The radar data allowed to determine the ice thickness and the bedrock topography in order to contribute to the imaging of the continent under the ice (International BedMap Projects). The Aurora trench deepest point (located at 118.328° E; 76.054°S) shows an ice thickness of 4755 m that represents one of the five thickest point measured by RES systems (Fig. 3).

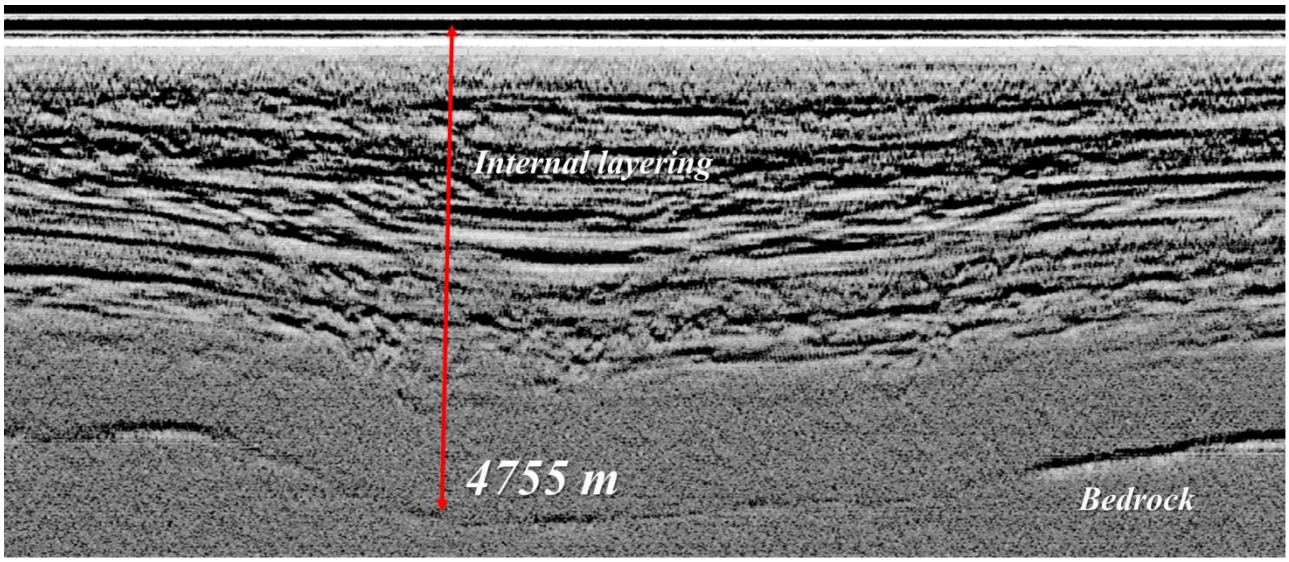

Figure 3 – Aurora Trench deepest point

During the 1999 and 2001 Italian Antarctic Expeditions, extensive airborne radar surveys were carried out over the region Vostok-Dome C and the Aurora trench (about 6000 km of radar tracks were acquired). The radar data allowed to determine the ice thickness and the bedrock topography over the entire area and permitted to identify 30 radar tracks as sub glacial "lake" mirrors (Fig. 4) and accepted them as new lakes in the international subglacial lakes catalogue.

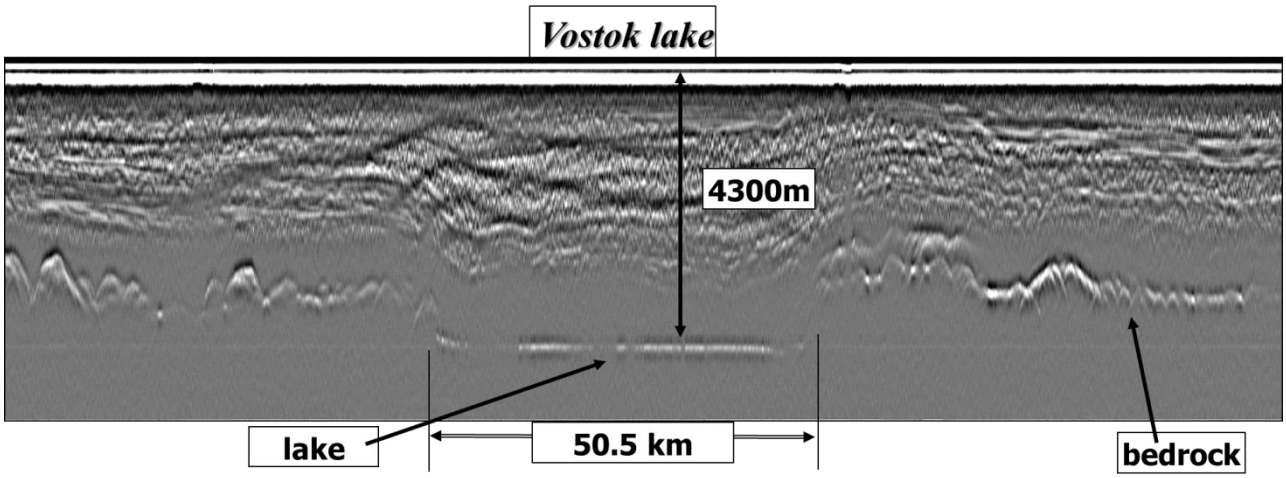

Figure 4 – Subglacial "lake mirror" reflection in RES data

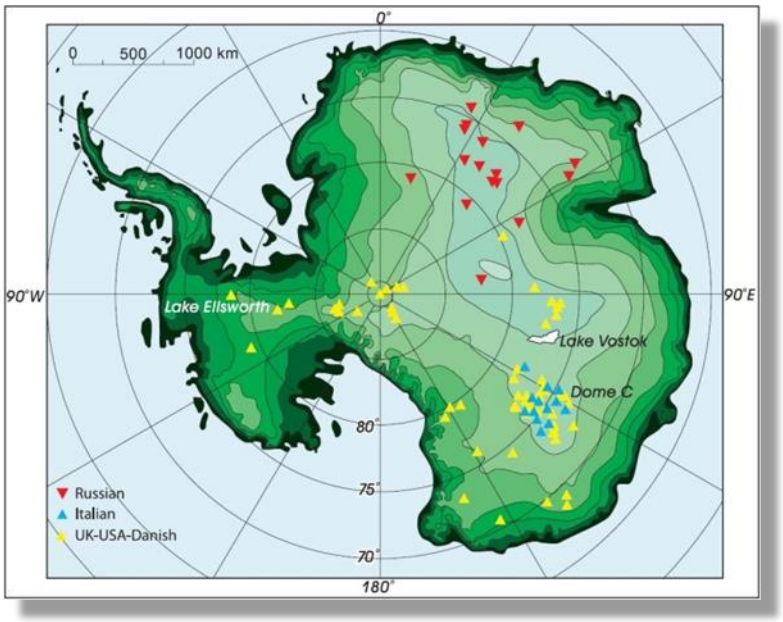

Figure 5 – Subglacial lakes distribution in Antarctica as from International catalogue.

Besides, the INGV RES system supported different international ice core projects such as the EPICA (European Project for Ice Coring in Antarctica , ITASE (International Trans Antarctic Scientific Exploration) and TALDICE (Talos Dome Ice Core). In fact, the knowledge of the detailed topography of these regions permitted in both cases to choose the optimal location for deep ice-core drilling.

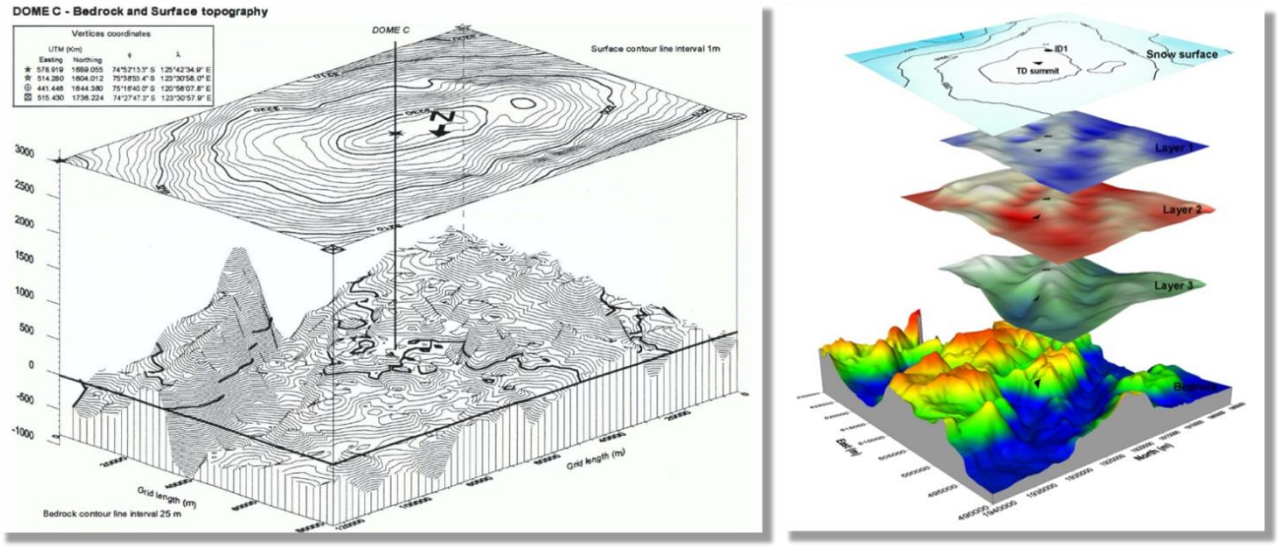

Figure 6 – On left, the bedrock topography reconstruction under EPICA ice drilling site; on right the bedrock and the internal layers undulation under TALDICE ice coring site.

In recent years, the presence of flowing water beneath ice sheets is an extremely important area of discussion, especially in climatological and glaciological studies. Several scientific papers describe numerous new subglacial lakes distributed over certain areas in Antarctica. Currently, more than 150 lakes are catalogued beneath the Antarctic Ice Sheets and many of them may be connected by hydrological network not yet completely known and understood. The bedrock characterization through RES data analysis has been improved by the analysis of radar echo strength. The analysis of the RES signal amplitude has been used to highlight areas of high reflectivity variation, attributable to wet ice-bedrock interfaces (Fig 7).

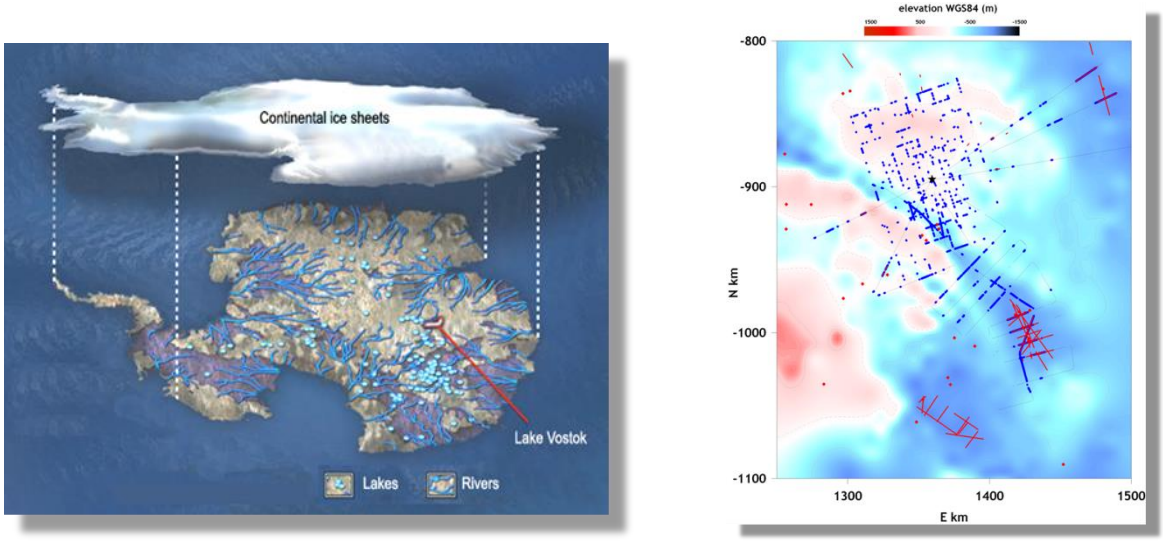

Figure 7 – On left, the Antarctica hydrological network derived from subglacial lakes and bright spot reflections distribution; On right an example of wet/dry analysis conducted through RES data in the Dome C area (blue point are for high energy returned and thus supposed wet)

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