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PRESS RELEASE

Paris, 26 March 2015

SUBGLACIOR: revolutionising paleoclimatology with a new type of probe

The purpose of the SUBGLACIOR project is to design, build and deploy a new type of in-situ ice-corer probe in the Antarctic in order to record, within a single season, the oldest available data on the earth's climate sourced from natural ice that formed over a million years ago.

Since 2011, teams from four French research laboratories have been working on the Subglacior project with support from the BNP Paribas Foundation : the Laboratoire de Glaciologie et Géophysique de l'Environnement (LGGE, CNRS/Université Joseph Fourier) [Laboratory for Environmental Glaciology and Geophysics], the Laboratoire Interdisciplinaire de Physique (LIPhy, CNRS/Université Joseph Fourier) [Interdisciplinary Physics Laboratory], the technical division of the Institut National des Sciences de l'Univers of CNRS [National Institute of the Sciences of the Universe] (DT-INSU) and the Laboratoire des Sciences du Climat et de l'Environnement (LSCE, CNRS/CEA/UVSQ) [Laboratory for Climate and Environmental Sciences].

SUBGLACIOR is the main focus of the International Partnerships in Core Ice Sciences, an organisation which brings together scientists from 23 countries working on ice cores. It is financed by the European Research Council (ERC), the Agence Nationale de la Recherche (ANR) [French National Research Agency], the Investments for the Future programme under the CLIMCOR project, and the Institut polaire français Paul-Emile Victor (IPEV) [Paul-Emile Victor French Polar Institute].

Throwing light on the last major climate system shift

The natural climate archives have shown that a radical change in climatic variability took place around a million years ago. The earth went from experiencing low intensity but frequent – every 40,000 years – periods of glaciation to longer and more pronounced periods of glaciation every 100,000 years. This change in the climate may be due to a major alteration in the concentration of CO₂ in the earth's atmosphere.

In order to verify this hypothesis and thus resolve one of the last great enigmas of climate history, glaciologists set out to retrieve samples of the oldest ice, which is located at the very bottom of the Antarctic mass, so as to analyse the air it contains. This reliable method enables scientists to

understand the mechanisms, non-linear variations and retroactive effects of this mid-Pleistocene climate shift.

With the drilling technology available today, efforts to attain the research objectives carry considerable risks of scientific inaccuracy due to the difficulty of identifying the right site for drilling – i.e. where the various layers of ice have not become mixed up. The task will take a number of years.

With their new approach, the SUBGLACIOR project team will be able to substantially reduce the risk of inaccuracy. The probe that is being developed will enable the scientists to explore the ice up to 3 kilometres deep in a single season in the field, i.e. 2 to 3 months, and collect precise real time data on the climate over the last 1.5 million years, concentrations of greenhouse gases and dust particles.

Development of the Subglacior probe

The probe's measurement capability is based on innovative French laser technology which enables key parameters, such as water isotopes and the concentration of methane in the air imprisoned in the ice, to be measured in real time relative to the drilling process by means of an instrument embedded in the corer. Progress in laser spectroscopy in the near and mid infrared ranges – OFCEAS-patented technology – means that ultra-precise measurements can now be obtained from an instrument compact and robust enough to be deployed in extreme conditions. As part of the SUBGLACIOR project, around twenty scientists and engineers on the team succeeded in miniaturising the laser instrument so that it could be inserted into a tube less than 5 centimetres in diameter. The data it will gather will be transmitted continuously to the surface via electronics embedded in the probe, and a specially designed cable 3,500 metres in length.

The SUBGLACIOR team is now developing an envelope which will allow the probe to drill down into the ice cap from the surface and produce continuous samples analysed by the laser spectrometer. The laser instrument was tested for the first time last summer, in an environment far from the polar ice. It was deployed to analyse gases dissolved in the Mediterranean Sea, using a specially-designed interface built at the LGGE. In fact the initial results look very promising for use in many areas of oceanography, a field far removed from research into ancient climate history. This deployment at depths of up to 600 metres off the coast of Nice allowed scientists to obtain for the first time a continuous profile of methane concentrations dissolved in the Mediterranean Sea, showing variations at the scale of just several dozen metres. It now remains to be established whether these variations are of biological origin or linked to sea currents.



First deployment of the instrument in the Mediterranean Sea.
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Next steps

Following a development phase lasting four years, the mechanical part of the probe was tested for the first time in situ during the winters of 2013-14 and 2014-15 at the Franco-Italian Concordia base station in Antarctica. A fully watertight tube system was for the first time installed down through the 120 metres of snow and névé covering the glacier. The tubing is necessary as the circulation of drilling fluid continually delivers to the surface ice shavings produced during drilling. Having tested this circulating fluid mixed with ice shavings, the scientists were able to show conclusively that the system is indeed watertight and that the core samples are not being contaminated.

The next expedition will take place during the 2015-16 winter. Logistics experts from IPEV will transport the heavy equipment – drilling fluid, winch, winch cable, drilling fluid feed hose, etc – to the Antarctic coast so that the probe can be set up at the Concordia base and tested in an on-site trial scheduled to take place the following year.

In parallel, research into gases dissolved in the oceans – an initially unforeseen application of these technological advances – is continuing. An important area for the team to focus on is the study of the release of gases from methane hydrates in the sea floor in the Arctic region as a result of global warming. Oceanographic researchers are very excited about the performance of the prototype instrument. The SUBGLACIOR team is now looking at the potential for creating a startup company to arrange manufacture and commercialisation this new French knowhow.

Project financing and organisation

The total budget for constructing the probe is around €3.2 million. BNP Paribas Foundation sponsorship totalling €100,000 enabled the four research centres involved to start work on designing the probe. The construction and on-site deployment of the probe in the Antarctic is being financed by the European Research Council through the ICE&LASERS project, the French National Research Agency under its 'Blanc' (Blue-sky) programme, CLIMCOR EquipEX (Equipment of Excellence) from the Investissements d'Avenir (Investments for the Future) programme and the Mamont Foundation, which recently joined the consortium. The Paul-Emile Victor French Polar Institute (IPEV) is handling the logistics for the Antarctic missions to deploy the probe.

For more information on the project go to: <http://www.iceandlasers.org>

About the partners:

The Laboratoire de Glaciologie et Géophysique de l'Environnement (LGGE) [Laboratory for Environmental Glaciology and Geophysics], a unit of the French National Centre for Scientific Research (CNRS) based at Joseph Fourier University in Grenoble.

For over 50 years, the LGGE has built a strong scientific reputation in the field of climate and atmospheric composition studies. LGGE researches into current conditions and traces past developments through the archives formed by the snow and ice that have accumulated over time. The LGGE is also a centre of cutting-edge knowhow on snow and ice, in such fields as the physical and mechanical study of ice material, air-snow chemical exchange, and data acquisition both on-site and via satellite. The Lab's research combines technological analytical developments with a digital modelling approach that can be applied to various fields, from the atmosphere to flows of ice mass.

LGGE's priority areas are the Antarctic and Arctic polar regions, but the Lab's expertise also extends to mountain regions: studying Alpine, Andean and Himalayan glaciers and Alpine valley pollution. This research contributes to human understanding of major scientific issues which are often also key issues for our society, including the greenhouse effect, variations in climate and the environment, the evolution of the cryosphere mass, pollution at global and regional levels, and glacier hazards.

Two years ago the LGGE set up a new team specialising in physical oceanography, which means, inter alia developing models for operational oceanography.

Some 150 people work at LGGE. These researchers, teachers, doctoral students, engineers and technicians carry out their work not only at the lab premises but also in the field – up mountains, at the poles and on the oceans – researching, teaching and helping to disseminate knowledge in areas of major interest for our society.

CNRS - <http://www.cnrs.fr>

Founded in 1939, the French National Centre for Scientific Research, which operates under the aegis of the Ministry of National Education, Higher Education and Research, is the largest governmental research organisation in France. Its purpose is to develop scientific knowledge and make this knowledge available to serve society. CNRS is in charge of over 1,100 research and service departments operating in all scientific fields and some 33,000 people work for the agency throughout France. CNRS has a long tradition of excellence and boasts 20 Nobel Prize winners and 12 Fields Medal winners.

European Research Council - <http://erc.europa.eu/>

The European Research Council (ERC), created in 2007 by the European Union, is the leading EU funding body for excellence in exploratory research. Every year the ERC selects and awards grants to projects headed by well-established or younger researchers, irrespective of their origins, who are working or moving to work in Europe. The ERC seeks to attract the best researchers worldwide to Europe. To date it has financed more than 4,500 first-rate researchers at various stages in their careers. As a flagship component of Horizon 2020, the European Union's Research Framework Programme running from 2014 to 2020, the ERC budget has now substantially increased to total over €13 billion.

French National Research Agency (ANR) – www.anr.fr/en

ANR provides funding for project-based research in all fields of science – for both basic and applied research – to public research organisations and universities, as well as to private companies (including SMEs). Since 2005, the agency has funded over 12,000 projects.

Employing a method based on competitive peer reviews that complies with international standards, ANR attaches great importance to providing the scientific community with instruments and conditions that promote creativity and openness, and stimulate new ideas and partnerships, particularly between academia and industry. Its activity also contributes to enhancing the competitiveness and the influence of French research in Europe and across the world. Since 2010, ANR has also been the principal operator of the Investments for the Future programme in the field of higher education and research. In this role it ensures the selection, funding and monitoring of projects relating to the centres of excellence, health, biotechnologies, and the transfer of technology and the creation of value from research.

Mamont Foundation - www.foundation-mamont.com

The Mamont Foundation was established in 2007 for the purpose of supporting the study of, and exploration in the polar regions. To this end, the Foundation initiates and encourages innovative projects with a view to

sharing the discoveries made in these fascinating regions in order to promote better understanding of the major role they play in climate evolution.

The BNP Paribas Foundation – www.fondation.bnpparibas.com

Under the aegis of the Fondation de France, the BNP Paribas Foundation has been playing a key role in corporate philanthropy for 30 years. It is also encouraging and contributing to the BNP Paribas' philanthropic policy growth in all parts of the world where the Group does business.

The BNP Paribas Foundation's activities are aimed at promoting innovative projects dedicated to culture, social inclusion and the environment. It is paying close attention to provide optimal support to its partners, through a long-term commitment. Dialogue, loyal support and a relationship based on trust are the hallmarks of its involvement.

Since it was set up in 1984, more than 300 cultural projects, 40 scientific research programmes and around one thousand social and educational initiatives have benefited from its support, in France and across the world.

The Climate Initiative programme- <http://bit.ly/ClimateInitiativefr>

The BNP Paribas Foundation is providing assistance to SUBGLACIOR as part of the Climate Initiative, a corporate philanthropy programme for research into climate change launched by the Foundation in 2010, in close liaison with the BNP Paribas Group CSR department. A total of ten climate change research projects have received, or are currently receiving, financial support under the Climate Initiative.

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