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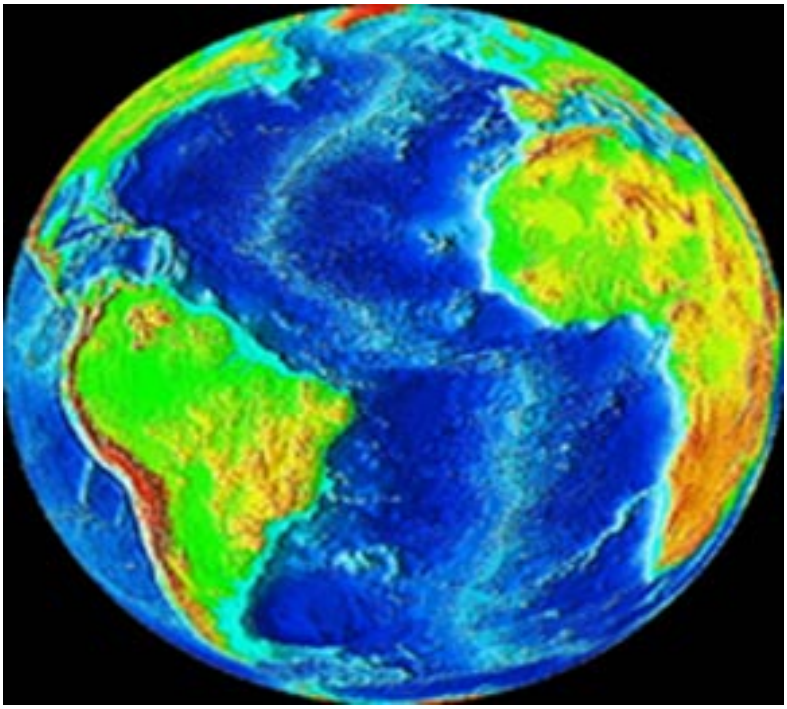
MARGO, a new tool to improve climate models



An international team of researchers, including Antoni Rosell, ICREA researcher at the Institute of Environmental Science and Technology (ICTA) and professor of the Department of Geography, Universitat Autònoma de Barcelona, who participated as a member of the direction team, has created MARGO (Multiproxy Approach for the Reconstruction of the Glacial Ocean Surface), a new quantitative reconstruction of the sea surface temperature during the Last Glacial Maximum. Project MARGO is the first step towards creating more precise reconstructions of the LGM period and predictions of climate change in the future.

Presented in the article «Constraints on the magnitude and patterns of ocean cooling at the Last Glacial Maximum» in *Nature Geoscience*, MARGO was created by 52 researchers from around

the world. In addition to Antoni Rosell members of the direction team included C. Waelbroeck (CNRS, France), A. Paul (U. Bremen, Germany), M. Kucera (University of Tübingen, Germany), R. Schneider and M. Weinelt (University of Kiel, Germany), and A.C. Mix (Oregon State University,United States). Isabel Cacho, professor of the Department of Stratigraphy, Paleontology and Marine Geosciences and member of the Marine Geosciences research group at Universitat de Barcelona also participated in the project.

Researchers use climate models to discover how to reduce the impact of climate change or how global warming increases in a specific area of the planet. These models are created with mathematic equations to create a quantitative representation of how the atmosphere, oceans and polar ice caps interact during a specific time period. "It is not always easy to verify if these models are reliable and efficient, especially when it comes to middle and long-term predictions. The safest way of doing it consists in modelling a climatic period which is very different from the one now, where you can observe the mechanisms from that period and verify that the reconstruction of the climate model is correct. With this, we make sure that the climate model will function correctly when predicting future climate situations", states Antoni Rosell, ICTA researcher, member of the direction team, instigator of the MARGO project and expert in geochemical paleothermometers.

During the 1970s scientists created the CLIMAP (Climate Long-Range Investigation, Mapping and Prediction) project; the first quantitative global reconstruction of sea surface temperatures during the Last Glacial Maximum, the coldest period of the last glaciation. Since then, CLIMAP has been used in all climate models which reconstruct the weather conditions from that period. But the evolution in climate science in the past years and the development of new data collection techniques and methods have made it obvious that thirty years after its creation, CLIMAP clearly does not suffice. This is evidenced by the research carried out with MARGO, which offers more precise data on sea surface temperature during the Last Glacial Maximum, especially in the Northern Atlantic Ocean and tropical areas, as well as a new perspective on the sensitivity of the Earth's climate system to carbon dioxide. It also represents a new tool which can improve the reliability of current climate models.

"MARGO's main contribution has been the mapping of sea surface temperatures which reconstruct longitudinal and latitudinal gradients of all ocean basins during the Last Glacial Maximum, and which can be quantitatively contrasted with current oceanographic conditions", explains Antoni Rosell. "These new maps have helped us identify aspects which can improve climate modelling and ways in which the main climate models used in future predictions can be enhanced, for example to represent certain climate situations in specific areas of the planet. We nevertheless detected that these tools are currently very reliable in general".

Researchers detected that the climate during the Last Glacial Maximum was characterised by pronounced east-west temperature gradients in the tropics and North Atlantic regions which are very different to today's temperatures. This implies significant changes in ocean and atmosphere currents due to the presence of large ice caps in Europe and North America.

Researchers defined their period of study between 23 and 19 thousand years before present, which is rigorously considered to be the Last Glacial Maximum period (CLIMAP had studied the period between 26 and 16 thousand years), and compiled up to 696 individual reconstructions of

sea surface temperatures from different parts of the world. The data was obtained with the analysis of up to six types of paleothermometers which analysed sediments found in the depths of the oceans and the fossil remains they contained. Of these, four paleothermometers were based on ecological principles and the study of the shells of microscopic organisms (planktonic foraminifera, diatoms, dinoflagellates and radiolaria); while the other two were geochemical and based on organic molecules (alkenones containing 37 carbon atoms) produced by unicellular algae or by metals found in the zooplankton shells (magnesium and calcium found in planktonic foraminifera).

The sea surface temperatures of the MARGO project were studied within a joint research framework defined by all 52 researchers. For the project, the planet was divided into a grid of 5º latitude x 5º longitude cells. Each cell was given a specific temperature resulting from the weighted average of the data collected in the different paleothermometers analyses corresponding to each grid cell. Data was collected mainly in the North Atlantic, Antarctic and tropical regions, considered key to the understanding of climate systems.

This greater precision in quantitative reconstructions provided by MARGO has allowed researchers to offer new views on the climate situation of that period. One of the most relevant aspects refers to the fact that the ice covering a large part of the northern hemisphere during the Last Glacial Maximum was not permanent - as CLIMAP stated - but actually melted in the warmer months. This facilitated an exchange of heat between ocean and atmosphere and favoured the growth and stability of large polar ice caps in Europe and North America.

In addition, while CLIMAP maintained that the most significant cooling (below -10ºC) occurred from the middle latitudes of the Northern Atlantic Ocean towards the west of the Mediterranean Basin (-6ºC), the MARGO project indicates that this cooling was produced in the opposite direction, from sea basins in the east towards those in the west and that the cooling was not the same in all areas but occurred in some areas to a larger degree than others. Researchers confirmed this hypothesis with the results of four types of paleothermometers, while CLIMAP only used one.

Regarding the cooling of the tropics, MARGO reveals that the area affected was much larger than that proposed by CLIMAP and more heterogeneous, with more pronounced cooling in the Atlantic than in the Indic and Pacific. Data obtained from MARGO specifically indicate a 1-3ºC cooling of the warmest area of the western Pacific. One of the remarkable features however is that temperatures in some areas were higher than they are today - albeit the Earth was experiencing a glaciation period - as was detected in the 1-3ºC difference in northwest Australia, probably due to the changes in direction of warm water routes along the Indonesian region. The subtropical currents of the Atlantic Ocean experienced little cooling in their centre (less than -2ºC), whereas in the Pacific, parts of both northern and southern subtropical currents were warmer than at present by up to 1-2ºC.

Researchers also concluded that there was a movement of polar ice caps in the Antarctic Ocean towards the north, which caused a cooling of -2 to -6ºC in comparison to current temperatures.

Project MARGO sets the bases for future joint international and interdisciplinary studies which will work towards a better understanding of the natural causes of climate change, ocean currents

and the atmosphere of both the past and the present, as well as the effects climate change will have in the future.

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