About 13,000 years ago, the water outflow from the Mediterranean to the Atlantic Ocean was twice that of today's

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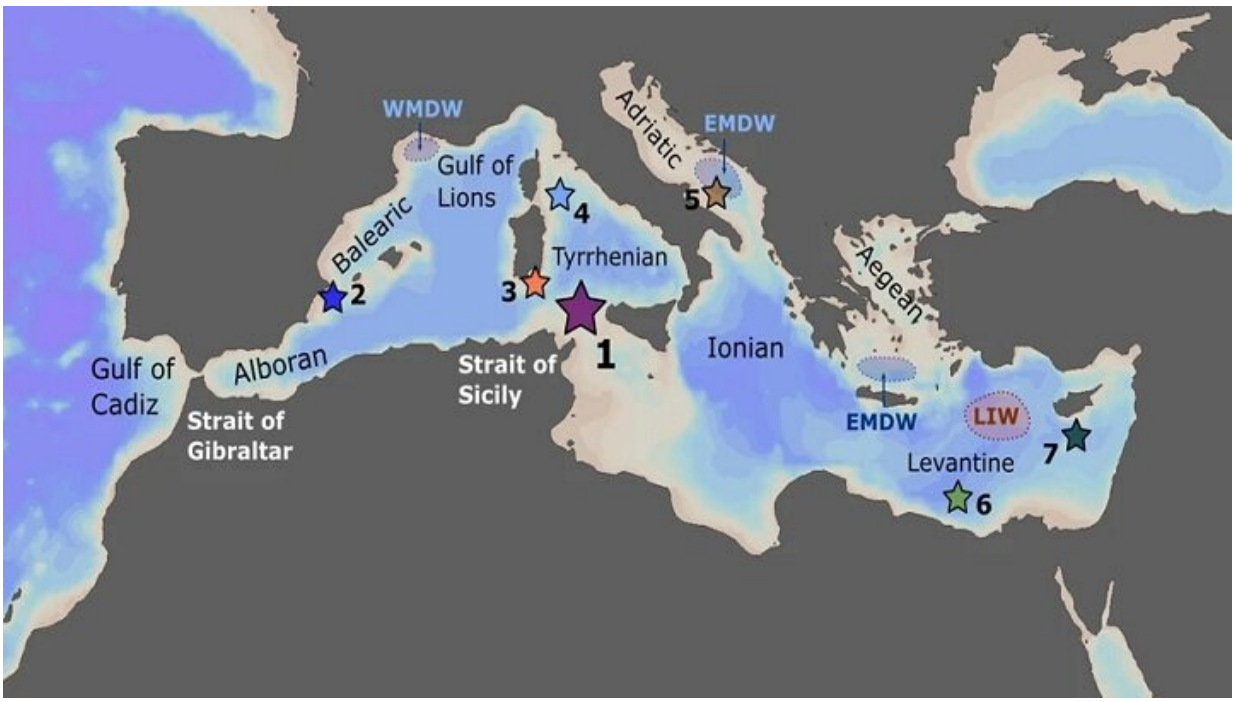

Studying the Younger Dryas could help predict the potential effects of global change in the Mediterranean at the end of the 21st century. Credit: University of Barcelona

About 13,000 years ago, a climate crisis caused a global drop in temperatures in the northern hemisphere. This episode of intense cold,

known as the Younger Dryas, also caused severe aridity across the Mediterranean basin, which had a major impact on terrestrial and marine ecosystems. But what do we know about the impact of this climate change on water circulation in the Mediterranean?

During the Younger Dryas, the flow of water masses from the eastern Mediterranean to the Atlantic Ocean through the Strait of Gibraltar doubled, according to a study published in *Communications Earth & Environment*. The work has applied the innovative technique of neodymium (Nd) isotopes to reconstruct the conditions in the Mediterranean since the last deglaciation, some 14,000 years ago.

The study is part of the doctoral thesis being carried out by Sergio Trias-Navarro, under the supervision of Professor Leopoldo Pena and Professor Isabel Cacho, from the consolidated research group in Marine Geosciences (GCR Marine Geosciences) of the Faculty of Earth Sciences of the University of Barcelona. The study presents some of the most relevant results of the European Research Council's TIMED project (ERC-Consolidator), and has an outstanding participation of members of the GCR Marine Geosciences, and experts from La Sapienza University of Rome, the University of Palermo (Italy), and the Swiss Federal Institute of Technology in Zurich (Switzerland).

The most intense climate change in 13,000 years

The Younger Dryas was the most intense climate change of the last 13,000 years and the most far-reaching on a planetary scale. Its end marked the end of the Holocene, the interglacial period in which we find ourselves today. "There has also been climate variability during the Holocene, such as the episodes known as the Little Ice Age, the Medieval Climatic Anomaly or the Roman Warm Period. However, this climate variability had a lower relative intensity with different regional climatic expressions, without the capacity to generate changes on a

global scale," says Professor Isabel Cacho, from the UB Department of Earth and Ocean Dynamics.

The paper also analyzes the last sapropel, a Holocene episode after the Younger Dryas linked to an extraordinary increase in rainfall in the Mediterranean region, especially in North Africa. The study provides the first quantification of changes in the deep circulation of the eastern Mediterranean during this episode, and it has estimated that it was reduced by up to a quarter compared to the Younger Dryas. Still, the experts explain that the impact this event may have had on the oceanography of the North Atlantic is unknown.

The new study supports the hypothesis that increased salt input from the Mediterranean into Atlantic waters during the Younger Dryas was key to reactivating the North Atlantic circulation: this led to a rapid warming in Europe and the Mediterranean, which marked the beginning of the Holocene.

"Mediterranean water masses are one of the primary sources of salt in the North Atlantic. Water salinity is an important factor in oceanography, as it determines the density of water masses. It is therefore a key process in the formation of deep waters in the Atlantic Ocean and is the driver of global ocean circulation," says researcher Sergio Trias-Navarro.

A technical innovation to study the oceans of the past

As in other previous studies conducted by the GRC Marine Geosciences, the team has applied the innovative technique of neodymium radiogenic isotopes as geochemical tracers to reconstruct the oceanographic conditions of the past. This analytical study has been carried out in the LIRA and PANTHALASSA laboratories, unique research support facilities in Catalonia located in areas of the Faculty of Earth Sciences

and the UB's Scientific and Technological Centers (CCiTUB) and coordinated by experts Leopoldo Pena and Isabel Cacho.

"Compared to other types of geochemical tracers, Nd isotopes have the great advantage of being conservative. Therefore, they do not interact with or are not affected by biological processes, for example, biological productivity or the degradation of organic matter," says Professor Leopoldo Pena, co-author of the paper. "This technique allows us to go beyond time and it can be applied to oceanographic reconstructions of both the present and the past. It allows us to understand the dynamics of the ocean and reconstruct oceanography long before we could observe or measure it ourselves with other scientific tools," adds the expert.

Younger Dryas: A mirror for the Mediterranean of the future?

There are still many enigmas about the potential impact of Mediterranean waters on the North Atlantic circulation. Despite the scientific interest, "much of the oceanographic studies focusing on the Atlantic Ocean do not consider the Mediterranean, and perhaps the role of Mediterranean waters in the Atlantic circulation has been downplayed," note the authors.

The latest report of the Intergovernmental Panel on Climate Change (IPCC) presents the Younger Dryas as an example of the predictable changes in rainfall that will take place in the Mediterranean as a consequence of an expected reduction in the circulation of the North Atlantic. "On the other hand, according to projections for the end of the 21st century, the Mediterranean circulation will weaken and, consequently, so will its contribution to the Atlantic Ocean," says Isabel Cacho, coordinator of the TIMED project. In the current context of climate change, studies such as this one are increasingly necessary to

better understand the sensitivity of the Mediterranean circulation to different climatic situations.

"The Younger Dryas is not a perfect analogue for future changes, as we are currently facing a much more amplified greenhouse effect. Still, our study reveals that the change in aridity which is expected by the end of the century is capable of inducing an intensification of the Mediterranean circulation, although the projected warming could counteract this effect. For this reason, we need to better understand the relative weight that these two variables—temperature and humidity—have had on the evolution of the Mediterranean circulation," concludes the research team.

More information: Sergio Trias-Navarro et al, Eastern Mediterranean water outflow during the Younger Dryas was twice that of the present day, *Communications Earth & Environment* (2023). DOI: 10.1038/s43247-023-00812-7

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