The Gulf Stream kept going during the last Ice Age

September 16 2014

The warm Atlantic water continued to flow into the icy Nordic seas during the coldest periods of the last Ice Age.

An ice age may sound as a stable period of cold weather, but the name deceives. In the high latitudes of the Northern Hemisphere, the period was characterized by significant climate changes. Cold periods (stadials) switched abruptly to warmer periods (interstadials) and back.

"It is widely thought that during cold periods of the last Ice Age the warm Atlantic water had stopped its flow into the Nordic Seas. The results of our recent study suggest that the Atlantic water never ceased to flow into the Nordic Seas during the glacial period," says Mohamed Ezat, PhD at Centre for Arctic Gas Hydrate, Environment and Climate (CAGE) at UiT, The Arctic University of Norway.

The study, published in *Geology*, documented that bottom water actually warmed up to up to 5°C at 1200 m depth in the Nordic seas during the cold stadials. Cold bottom water temperatures of 0,5°C was observed during the warm interstadials, which is fairly similar to what we have today.

How is this possible?

So the air was getting colder, but the deep ocean water was getting warmer, during the coldest periods of the Ice Age. How is this possible?

Colloquially referred to as the Gulf Stream, the warm North Atlantic Current is partly responsible for our mild North European winters. It flows into the Nordic seas, where it cools down in winter and releases heat to atmosphere. It becomes denser and sinks to the bottom of the Nordic seas. It forms an important part of the global circulatory system of ocean currents.

"Cold, deep water from this little area of the Nordic seas, less than 1% of the global ocean, travels the entire planet and returns as warm surface water. This has been a fairly stable process for the last 10 000 years. The events here are significant for the entire ocean system. But if we go back to the Ice Age things were quite different, says professor Tine Rasmussen from CAGE. The reason was that ice sheets across Scandinavia and North America produced a large amount of fresh melt water from icebergs. This means that the surface water could not achieve the required density to sink – this is a process that depends on salinity. The warm Atlantic water was saltier, and therefore heavier and subducted at depth and reached to the bottom, actually heating up beneath a lid of ice and melt water, that prevented the release of heat to the atmosphere.

"Warm water was there, but deep under the cold, icy surface. So the climate experience was colder, as the atmospheric records from Greenland ice cores show. But what eventually happened, is that the warm water reached a critical point, surged upwards to the surface, and contributed to the abrupt warming of the surface water and atmosphere," says Ezat.

Micro-thermometers

Prof. Rasmussen suggested this already in 1996 and a conceptual model was published in 2004.

"Our results were debated, because we didn´t have exact temperature measurements. Ezat and co-authors applied a new method to measure the exact temperature from the sediment cores collected north of the Faroe Islands," says professor Rasmussen.

The temperature is measured in the shells of single celled organisms called benthic foraminifera. When they die the shells become a part of the ocean sediment. The temperature of their lifetime stays inscribed in the chemistry of their shells, making them micro-thermometers that reveal climate of the ages gone by.

"The amount of magnesium in the shells of specific species of foraminifera depends primarily on temperature. By measuring the ratio of magnesium to calcium we can estimate changes in temperature. We were lucky to find a continuous record of well-preserved benthic species for the analyses," says Ezat.

Significant for future climate

Understanding what happened with our ocean systems during the Ice Age, helps us understand what may happen to them if ice on Greenland and Antarctica melts in the future. Fortunately, the ice sheet over Greenland is much smaller than the ice sheet during the Ice Age and thus with less potential to seriously disturb the system.

"It is however, imperative to consider recent localized changes around Greenland and Antarctica in the light of our results. The basal melting due to subsurface warming represents an important component of the current ice mass loss," Ezat points out.

"Also, increase of melt water in the East Greenland Current may cause a weakening in the deep convection in the Nordic Seas. This may cause a warm subsurface inflow that may reach bottom on the East Greenland slope. Such a scenario, though very uncertain, has the potential to influence the stability of gas hydrates on the slope.

"Gas hydrate is essentially frozen methane gas under the ocean floor. If it melts it has a potential to release huge amounts of this hyper potent green house gas."

More information: "Persistent intermediate water warming during cold stadials in the southeastern Nordic seas during the past 65 k.y." Mohamed M. Ezat, Tine L. Rasmussen and Jeroen Groeneveld. *Geology*,2014.

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Provided by University of Tromso