New evidence on terrestrial and oceanic responses to climate change over last millennium

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Two sea bed loggings from the Alboran Sea have been analyzed at very high resolution and have allowed to reconstruct climate and oceanographic conditions as well as anthropogenic influence in the westernmost region of the Mediterranean Sea over that period. Credit: UGRdivulga

A multidisciplinary research team including University of Granada (UGR) researchers has analyzed two sea bed loggings retrieved from the Alboran Sea's basin at very high resolution and reconstructed climate and oceanographic conditions over the last millennium, including the anthropogenic influence in the westernmost region of the Mediterranean Sea.

Global warming, climate change and their effects on health and safety are probably the worst threats in mankind's history. Recent reports from the Intergovernmental Panel on Climate Change (IPCC 2007, 2014) have accumulated scientific evidence that the observed rise in mean ground temperature all over the world from the beginning of the 20th century is probably due to anthropogenic influence.

Moreover, global mean concentration of carbon dioxide in the atmosphere has risen since the industrial revolution due to human activities. This concentration has surpassed that found in ice cores over the last 800 000 years. In January 2016, NASA and the U.S. National Oceanic and Atmospheric Administration (NOAA) revealed that global mean temperature in 2015 was the highest since 1880, when records began.

Reconstructions of the global ground temperature in the Northern Hemisphere over the last millennium show hotter conditions during the so called Medieval Climatic Anomaly (800-1300 A.C.) and cooler temperatures during the Little Ice Age (1300-1850 A.C.).

Natural climate variability

Climate models give us a coherent explanation of the progressive cooling over the last millennium due to a natural climate variability (solar cycle changes and volcanic eruptions). However, we can see that this global tendency has reverted during the 20th century. Climate models are not capable of simulating the fast warming observed during the last century without including human impact along with natural mechanisms of climate forcing.

With this in mind, a multidisciplinary team of researchers has conducted a study reconstructing climate and oceanographic conditions in the westernmost region of the Mediterranean Sea. For that purpose, they have used marine sediments retrieved from the Alboran Sea's basin.

As a semi-closed basin located in a latitude affected by several climate types, it's especially sensitive and vulnerable to anthropogenic and climate forcing. Several organic and inorganic geochemical indicators have been integrated in the model for this research, thus deducing climate variables such as sea surface temperature, humidity, changes in vegetation cover, changes in sea currents, and human impact.

These indicators have shown consistent climate signals in the two sea bed loggings—essentially hot and dry climate conditions during the Medieval Climatic Anomaly, which switched to mostly cold and wet conditions during the Little Ice Age. The industrial period showed wetter conditions than during the Little Ice Age, and the second half of the 20th century has been characterized by an increasing aridity.

Climate variability in the Mediterranean region seems to be driven by variations in solar irradiation and changes in the North Atlantic Oscillation (NAO) during the last millennium. The NAO alternates a positive phase with a negative one. The positive phase is characterized

by western winds, which are more intense and move storms towards northern Europe, which resulted in dry winters in the Mediterranean region and the north of Africa during the Medieval Climatic Anomaly and the second half of the 20th century.

In contrast, the negative phase is associated with opposite conditions during the Little Ice Age and the industrial period. Our records show that during NAO prolonged negative phases (1450 and 1950 A.C.), there occurred a weakening of the thermohaline circulation and a reduction of "upwelling" events (emergence of colder, more nutrient-rich waters). Anthropogenic influence shows up in the unprecedented increase of temperature, progressive aridification and soil erosion, and an increase of polluting elements since the industrial period. On a broad scale, atmospheric circulation patterns, oceanic circulation patterns (the NAO and the Atlantic meridional overturning circulation), and variations in solar irradiance seem to have played a key role during the last millennium.

Results show that recent climate records in the westernmost region of the Mediterranean Sea are caused by natural forcing and anthropogenic influence. The main conclusions derived from this research have been published in a special volume of the *Journal of the Geological Society of London* about climate change during the Holocene.

More information: V. Nieto-Moreno et al, Palaeoclimate and palaeoceanographic conditions in the westernmost Mediterranean over the last millennium: an integrated organic and inorganic approach, *Journal of the Geological Society* (2015). DOI: 10.1144/jgs2013-105

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