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Natural and anthropogenic variations in methane sources during the past two millennia

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Abstract

Methane is an important greenhouse gas that is emitted from multiple natural and anthropogenic sources. Atmospheric methane concentrations have varied on a number of timescales in the past, but what has caused these variations is not always well understood^{1,2,3,4,5,6,7,8}. The different sources and sinks of methane have specific isotopic signatures, and the isotopic composition of methane can therefore help to identify the environmental drivers of variations in atmospheric methane concentrations⁹. Here we present high-resolution carbon isotope data ($\delta^{13}\text{C}$ content) for methane from two ice cores from Greenland for the past two millennia. We find that the $\delta^{13}\text{C}$ content underwent pronounced centennial-scale variations between 100 BC and AD 1600. With the help of two-box model calculations, we show that the centennial-scale variations in isotope ratios can be attributed to changes in pyrogenic and biogenic sources. We find correlations between these source changes and both natural climate variability—such as the Medieval Climate Anomaly and the Little Ice Age—and changes in human population and land use, such as the decline of the Roman empire and the Han dynasty, and the population expansion during the medieval period.