Radiocarbon variations in tree rings and climate change

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Current climate models largely downplay the role of solar activity in climate variability, focusing instead on anthropogenic greenhouse gas emissions as the primary driver of recent temperature increases. This is due to the understanding that changes in solar irradiance (±0.1%) are too minor to account for the significant warming observed in recent decades. However, several centuries ago, pronounced solar minima - such as the Maunder, Spörer, Wolf, and Dalton minima - may have had a more substantial impact on Earth's climate. Historically, major climate shifts have been linked to Sun-Earth interactions governed by astronomical cycles (Milankovitch cycles), which drive climate changes over timescales longer than 10 ky. A notable exception is the Holocene epoch (the last ~12 ky), during which Earth's temperature has been unusually high and stable compared to previous periods of rapid changes. The last major cold period (an ice age) ended roughly 11 ky ago. While another ice age would be expected, this natural cycle may be disrupted by human influences as atmospheric CO_2 levels reached 423 ppm in 2024 and continue to rise, as no global consensus on reducing emissions has yet been achieved. The recently proposed Anthropocene epoch (beginning in 1950) is likely to continue exhibiting high global temperatures. Other natural factors, such as volcanic eruptions, forest fires, and permafrost thawing, may also contribute to climate changes.

Major climate events over the past millennium, such as the Medieval Warm Period and the Little Ice Age, are clearly reflected in tree-ring $\Delta^{14}C$ records. The aim of our study is to search for similar climate events based on ^{14}C records measured for the previous millennia. The future trajectory of Earth's climate will depend not only on our success in curbing greenhouse gas emissions, but also on how natural forces influence long-term climate evolution. Although solar variations are currently considered a secondary factor compared to greenhouse gases, our understanding of their indirect and cumulative effects remains limited. Continued research is needed to better evaluate the full range of natural drivers influencing climate change over various timescales.