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Tracking atmospheric carbon emissions in southern Ontario, Canada using dendrochronological records

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Records of environmental change are often temporally short, perhaps spanning a few decades. For many environmental issues impacting the world today, we have very limited observations or data concerning those changes. Therefore, we need to supplement the short observational and instrumental records of environmental change with proxy data sources. Tree-ring growth records are one type of proxy data source that can be examined at annual timescales to track changes in the environment across longer periods than afforded by relatively short observations and instrumental data records. Changes in the composition of some gases in the atmosphere, are one example of environmental change that can be elucidated using tree-ring records. Trees utilize various forms of carbon dioxide during photosynthesis, including radiocarbon (^{14}C). Naturally, ^{14}C in the atmosphere varies through time due to cosmic ray flux and ocean-atmosphere dynamics. The concentration of ^{14}C also varies due to anthropogenic activities, including burning of fossil fuels, nuclear bomb testing, and the operation of nuclear power plants (NPPs). Tree rings record atmospheric ^{14}C concentration during the growing season and are an effective tool to trace ^{14}C in the atmosphere from a variety of sources, including NPPs.

In Southern Ontario, Canada there are 15 operational CANDU reactors at three NPPs (Bruce (8), Darlington (1) and Pickering (6)). Southern Ontario is also one of the most densely populated regions of Canada and is a major source of fossil fuel derived carbon that is depleted in ^{14}C. Monitoring of atmospheric ^{14}C in Ontario is conducted at the Centre for Atmospheric Research Experiments, operated by Environment and Climate Change Canada (ECCC). The facility is considered a clean air site, located approximately halfway between the Bruce and Darlington NPPs.

We measured the Δ^{14}C in tree rings from white spruce (Picea glauca) trees sampled across a west-east geographic transect between the NPPs with the aim of better understanding how the atmospheric concentration of ^{14}C has varied locally in this region, while also attempting to pinpoint sources of ^{14}C emissions. Data from our clean-air sites track globally derived ^{14}C data from the Jungfraujoch clean-air atmospheric sampling site in Switzerland. Tree-ring ^{14}Cmeasurements from our most densely populated site near the city of Toronto are depleted in ^{14}C, reflecting fossil fuel combustion. Conversely, ^{14}C measurements at our site nearest the Pickering and Darlington NPPs

are the most enriched. Our results give insight into how tree rings record ^{14}C and how well they compare to established atmospheric sampling techniques.