Tree rings provide vital information for improved climate predictions

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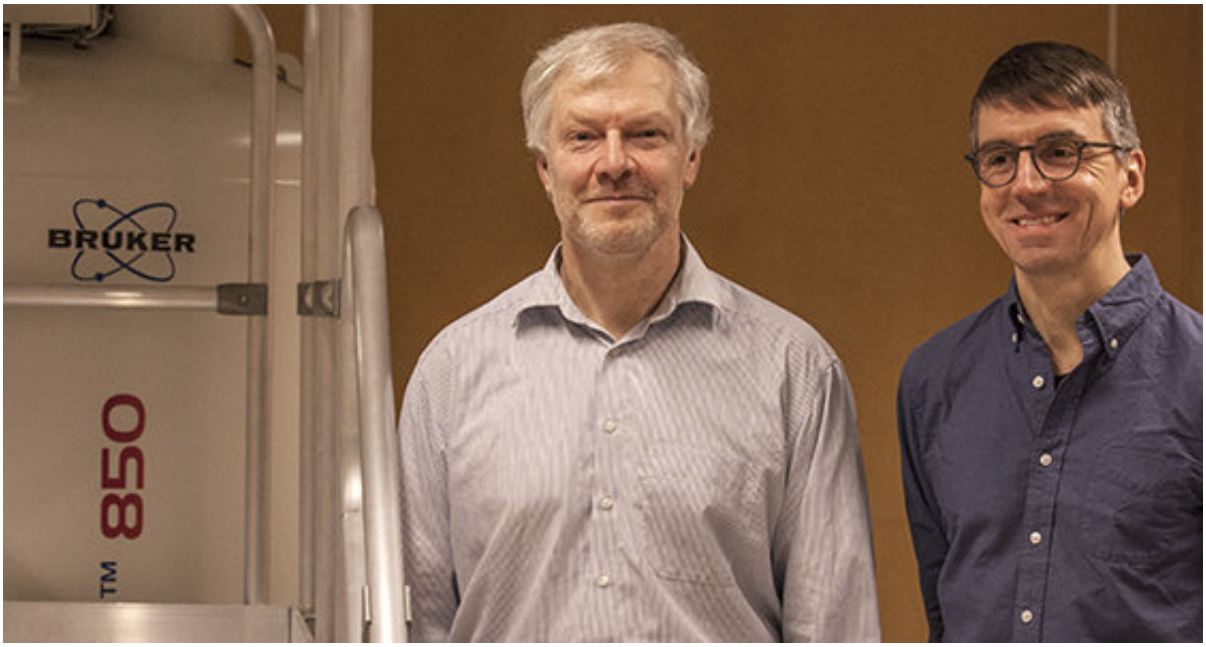

Jürgen Schleucher (left) and Thomas Wieloch (right), the first author and the head of the research project. Credit: Eva-Maria Diehl

Due to their worldwide distribution, trees have an extraordinary role in removing excessive amounts of CO_2 released into the atmosphere by human activity. So far, however, no tool exists to precisely calculate the carbon dioxide uptake of trees over their whole lifetime. Using a decade-long sequence of annual growth rings from pine trees, scientists at the NMR Centre at Umeå University's Chemical Biological Centre, (KBC) have introduced a highly advanced technique for tracking the carbon

metabolism of plants and its environmental controls. This technique lays the foundation for much improved parameterizations of climate change and global vegetation models.

Carbon dioxide (CO_2) uptake by plant photosynthesis is generally seen as a way to counteract steadily increasing concentrations in atmospheric CO_2 and climate change. In short-term experiments, elevated CO_2 has been found to increase photosynthesis, but it is uncertain if this fortuitous effect will persist over the coming decades and under changing climates.

Researchers at the Department of Medical Biochemistry and Biophysics at Umeå University have been working in recent years to develop methods that allow for refinement of climate models, to assess the role of plants to reduce the carbon dioxide concentration in the atmosphere, and also to elucidate how plant metabolism is affected by climate change. These questions cannot be answered using short-term experiments, therefore the Umeå researchers use archives of plant material, and search for traces of processes over decades. In previous publications, the research group of Juergen Schleucher showed that vegetation models should consider the entire metabolism of the plants. They previously used historic plant material in herbariums to study the development of photosynthesis and metabolism in plants over a longer period of time and thus were able to make predictions for the future under changed climate conditions.

With their latest publication in the journal *Scientific Reports*, Thomas Wieloch and his colleagues in Umeå, Austria, Switzerland and the U.S. report an innovative method to look into a tree's metabolism over its whole lifetime. Like using a microscope instead of a magnifying glass, the NMR specialists measured carbon isotope (13C / 12C) ratios at all six individual C-H positions in photosynthetic glucose. This is in contrast to conventional techniques, which do not resolve individual C-H

positions, but determine an average value over all glucose positions. In a tree-ring series of black pine (Pinus nigra), the team found several novel signals that report on metabolic processes in addition to CO_2 uptake. Thus, the new approach extracts more well-defined signals, and multiplies the information content of plant archives such as tree rings.

The scientists then looked at tree-rings of 11 tree species distributed around the globe. "Our results from 11 trees species show that the 13C / 12C ratios at individual C-H positions leave a fingerprint of the regulation of metabolism, which seems to be similar for all species," said Thomas Wieloch.

"We detected several so far unknown 13C signals in the cellulose molecules of our annually resolved tree-ring samples. This means that besides CO_2 uptake, other metabolic processes also influence 13C / 12C ratios at individual C-H positions, and signals reporting on these processes can be retrieved from tree-ring series. Tree-ring series can cover thousands of years, so even questions on this timeframe can be tackled," explains Thomas Wieloch.

"This study shows that we are able to look into the metabolic history of trees with much higher resolution, so that we possibly can detect if trees acclimate under changing climates," says Professor Juergen Schleucher, one of the two directors of the NMR Center in Umeå. "We really hope that our discovery that 13C / 12C ratios vary among the individual C-H positions of tree-ring cellulose will yield improved interpretations of 13C / 12 C isotope signals for the global carbon cycle. Based on this recent study, we will now go on to propose physiological mechanisms for the origins of the new metabolic signals, so that eventually we can decipher how increasing CO_2 in combination with changing climate affect tree growth over decades."

"This newest NMR research results from Umeå could be very relevant to

forestry because it could give climate researchers better background facts for their models and give decision-makers new ideas on how to adapt their forest management plans and make estimates of tree production more realistic," says Juergen Schleucher.

More information: Thomas Wieloch et al, Intramolecular 13C analysis of tree rings provides multiple plant ecophysiology signals covering decades, *Scientific Reports* (2018). DOI: 10.1038/s41598-018-23422-2

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