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Long-term growth trends and time series of elemental wood composition from two old-growth forests – natural versus anthropogenic influences

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In contrast to extreme environments with low human impact, where often one specific (climatic) factor is limiting tree growth, dendrochronological research in the temperate zone has to cope with a wide variety of climatic and non-climatic drivers. Sophisticated statistical tools, like various detrending and filtering techniques, allow for a rather precise analysis of high-frequency (annual) climate−growth relationships. However, as almost all forests in the temperate zone are to some degree influenced by human activities, it is difficult to separate anthropogenic from climatic influence on the lower time-frequencies of decades to centuries. Footprints of human activity in time series of tree-ring parameters might be caused directly through forest utilization (logging) or indirectly through environmental changes such as eutrophication or atmospheric pollution. The former can be elucidated by traditional dendrochronological techniques based on ring parameters; evaluation of the latter requires additional proxies such as dendrochemical data. For the interpretation of long-term trends and the calibration of tree-ring based reconstructions it is therefore necessary to study tree growth in as undisturbed forest environments as possible. Comparison with dendrochronological time series from managed forest might then allow separation of climatic- from anthropogenic signals.

Here, we present long-term growth trends for the broadleaved tree species common beech, pedunculate oak and sycamore maple, from two protected old-growth forests in northern Germany (one with a documented last logging activity dating back to 1527), and compare those with well-replicated regional chronologies from other, mostly managed forests. Our results indicate that several low frequency trends that can be found in many regional chronologies are likely caused by synchronous periods of heavy loggings as for example during the years following World War II, and do not relate to climatic drivers.

In addition, elemental wood composition of trees growing on an island relatively isolated from agricultural depositions or direct atmospheric pollution is compared to elemental concentrations in the wood of trees from a forest surrounded by intensive agriculture in the vicinity of Greifswald, a medium-sized town in Germany. The aim is to detect historical changes in soil chemistry attributable to either atmospheric depositions or groundwater input of nitrogen or sulphur. Therefore, high-resolution (50 μm) X-ray fluorescence (XRF) analysis is carried out and species-specific annual chronologies of relative concentrations of the most abundant elements as well as of different indicative element-ratios are built. We discuss our findings in the light of ongoing soil acidification that might be responsible for some of the detected trends (e.g. decrease in base cations like Ca or Mn), while considering possible radial translocation processes in the wood that might blur the obtained dendrochemical data.