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How do proxy reconstruction artifacts contribute to the outcome of paleoclimate model benchmarking?

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Continental climate reconstructions are frequently used as a paleo-data target to evaluate and benchmark climate models as well as to estimate climate sensitivity, and thus constrain the range of future climates. These efforts have to rely on the fidelity of the paleo-climate reconstruction and the associated uncertainty estimates. As for all paleoclimate proxies, for bioindicator-based Holocene climate reconstructions, the attribution of the proxy response to specific climate variables is a major source of uncertainty.
While it is technically possible to reconstruct any variable (e.g. summer, winter, July, or January 13^{th} temperature), in reality, only a single or a small subset of climate variables control the proxy response. Reconstructing the wrong variables introduces unknown errors.
Here, we provide for the first time a systematic investigation of this effect on Holocene pollen-based temperature reconstructions, using an ideal model experiment. We analyze simulated vegetation and climate from an orbitally-forced late Holocene ECHAM5/MPIOM model run (Fischer Jungclaus, 2011) in order to evaluate transfer-function techniques that are commonly used for pollen-based climate reconstructions. This allows us to assess the skill of reconstructions using the true model past.
In our model world, summer temperatures can be reconstructed in most regions with reasonable skill, whereas winter temperature reconstructions largely fail. Precipitation is only reconstructible in some areas of the tropics. Modern climate/vegetation data, used in the development of the transfer functions, is not sufficient to identify which climate variables can be reconstructed, but downcore fossil records can provide a constraint.
The tested transfer-function reconstruction methods pull the modern spatial covariances between climate variables into the downcore temporal reconstructions. As a consequence, temporal changes of a dominant climate variable (for the Northern hemisphere: often summer temperature) are imprinted on a less important variable (here: often winter temperature), leading to reconstructions biased towards the dominant variable's trends. We assess the significance of such "variable attribution" effects for quantitative continental CMIP5 model-data comparisons, and discuss the implications for inferences on model quality and/or climate sensitivity.