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Improved quantitative reconstruction of temperature during the Younger Dryas cold period in Northern Europe using botanical fossils

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Quantitative palaeo climate reconstructions are fundamental for our knowledge about magnitude and speed of past climate variability. Comparisons of such data with model simulations improve our understanding of the potential causes and processes of past climate variability. Of particular interest is the reconstruction of cold periods such as the so-called Younger Dryas (c. 12.600-11.500 years BP), because climatic conditions and variability during such periods was significantly different from today.

Botanical proxies are widely used as proxy for quantitative palaeo climate reconstructions. However, substantial challenges have to be coped with. A major challenge is that only present conditions can be used for determining vegetation-climate relationships. Climate in Europe was very different during the Younger Dryas compared to today, leading to a no analogue-situation. Vegetation-climate relationship as determined for vegetation in Europe today is therefore very problematic to be used for reconstructing climate of the Younger Dryas.

Here a solution to this problem is proposed. Presence of individual plant taxa is used rather than the abundance of their pollen. This enables the use of a wider range of climatic conditions, because geographic areas beyond Europe can be included. In addition, using presence minimizes the problem of non-analogous plant communities. The relation of the taxa to climate is estimated in a probabilistic way. The approach allows the use of macrofossilis which have the advantage over pollen that they have a higher taxonomic resolution. Good macrofossil data, however, are rare.

In contrast, numerous pollen data are available in Europe. These, however, have the severe problem that cold-adapted plant taxa as they can be determined by pollen analysis generally occur within a wide temperature range. A consequence is a large uncertainty in the reconstructions with insignificant differences between the Allerød and Younger Dryas (compare contribution by Simonis et al). The new approach reduces the uncertainty by including additional background information about the general vegetation type. Reconstructions with data from a Norwegian site were performed from which excellent macrofossil as well as pollen data is available.

The reconstructions deviate from previous reconstructions using other methods, particularly for winter temperature. Mean winter temperature was about 25°C lower than it is today in the area. This is in concordance with geological evidence. July temperature was only several degrees lower than today. The much more pronounced seasonality compared to today can be understood by the extent of sea ice which reached considerably further south than today and caused a very reduced if not absent North Atlantic current, leading to cold winters. Summer temperatures were less affected, because summer insolation during the Younger Dryas was even higher than today.

Recent developments include the reconstruction of climatic fields (see contribution by Simonis et al.). A worthwhile next step will be to apply the new approach to palaeobotanical investigations from the Younger Dryas of whole Europe and to compare the results with simulation output from climate models.