

# Recurrent rapid climatic changes in Western Europe during the Holocene imprinted into isotopic tracers of organic sediments from Lake Holzmaar

Andreas Lücke<sup>1</sup>, Holger Wissel<sup>1</sup>, Heinz Vos<sup>1</sup>, Jörn Parplies<sup>1</sup>, Robert Moschen<sup>1</sup> & Janina Baier<sup>2</sup>

<sup>1</sup>Institut für Chemie und Dynamik der Geosphäre V: Sedimentäre Systeme, Forschungszentrum Jülich, D-52425 Jülich

<sup>2</sup>Sektion 3.3 - Klimadynamik und Sedimente, Geoforschungszentrum Potsdam, Telegrafenberg, D-14473 Potsdam

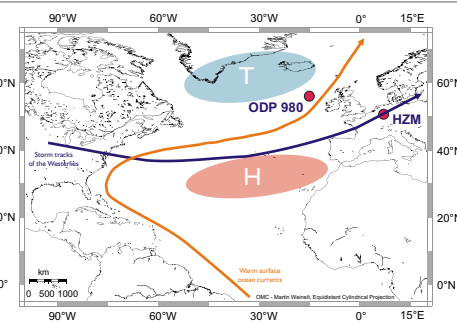
## Introduction

Climate conditions in Europe are governed by a variety of factors. Under present day conditions the contributions of those different elements to the overall thermal budget are well known. Absolute zonal-mean temperatures north of 35°N are additionally maintained by the seasonal heat release from the ocean (45%), the atmospheric heat transport (45%) and the ocean heat transport (10%) (Seager et al., 2002, Q.J.R. Meteorol. Soc. 128). Natural and anthropogenic ecosystems depend on this natural energy supply and larger variations in distribution between and amount of these sources might have severe consequences. Questions are, therefore, how this thermal budget varied in the past, what extend of variation was reached and which were the causes for the observed changes.

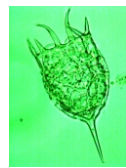


Lake Holzmaar view from the South

North Atlantic air pressure systems and major warm oceanic currents



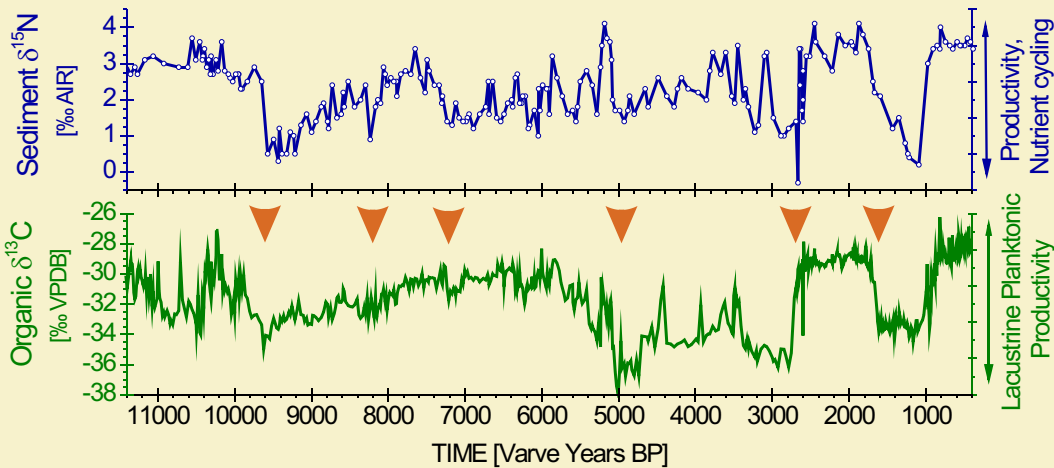
## Lacustrine zooplankton



Rotifers



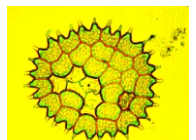
Copepoda



## Lacustrine primary producers



Diatoms  
*Fragilaria crotonensis*

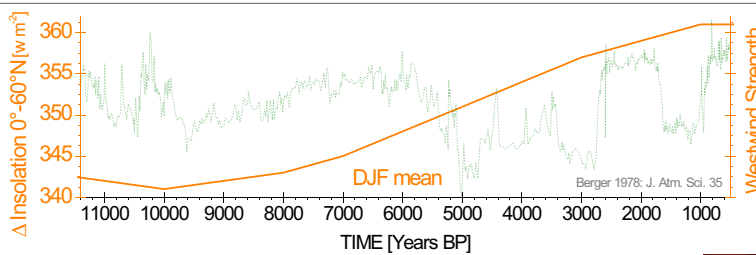


Green algae  
*Pediastrum boryanum*

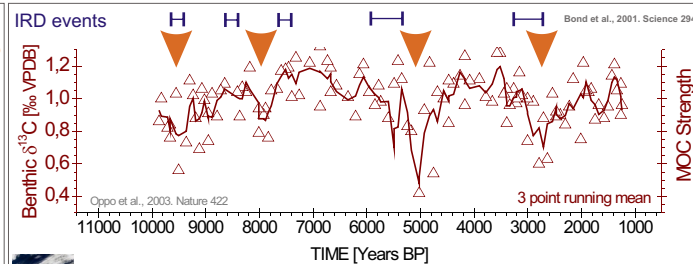


Cyanoprocarota  
*Planktothrix rubescens*

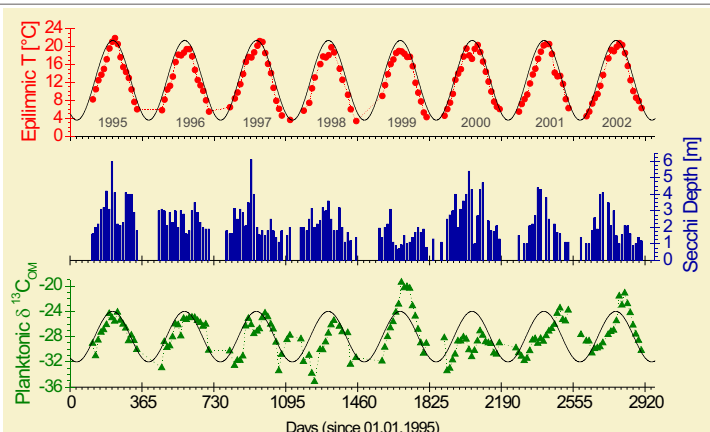
The organic part of the varved sediment record of Lake Holzmaar (HZM) is dominated by organic and microfossil remains of lacustrine primary producers (Lücke et al., 2003, QSR 22; Baier et al., 2004, QI 113). The lacustrine system of HZM is tightly coupled to the weather and climate development due to its genesis in a small maar crater and its position in the landscape. Carbon isotope values of organic matter describe amount of and conditions for lacustrine primary production which in turn strongly reflect the respective climate characteristics. Nitrogen isotope values confirm this interpretation and further develop the climatic significance of the HZM profile by revealing further details about nutrient availability and cycling in the lake. Major climate events are indicated by orange arrows.



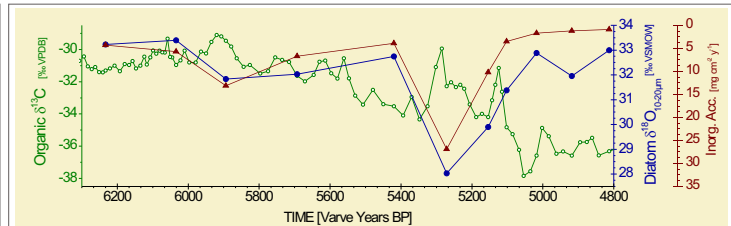
Insolation differences between the tropics and the high mid-latitudes are the principal cause for the development of the Westerlies and of the associated pressure systems. This insolation difference between 0° and 60° N steadily increased during winter (DJF) throughout the Holocene and is interpreted as cause for the long-term trend in carbon isotopes of HZM.



The carbon isotope composition of benthic foraminifers from a marine sediment core off the British Isles (ODP 980) are interpreted by Oppo et al. 2003 to reflect the contribution of North Atlantic bottom water to total flow at the study site. IRD events describe the massive occurrence of ice bergs in the North Atlantic.



Recently, the seasonal course of lake water temperatures did not change remarkably. Albeit, carbon isotopes show clear variations which are ascribed to productivity changes by comparison with the Secchi disk transparency. Such high frequency changes can not be the cause for observed changes in the HZM profile since we only resolve 10-15 year averages.



δ¹⁸O values of diatoms from HZM reveal a strong oscillation around 5300 years BP interpreted as distinct increase in discharge with a slower recovery.

## Conclusion & future prospects

- Millennial climate change in Western Europe is revealed in excellent resolution and quality by isotope proxies of HZM. Explicit identification and quantification of the main driving forces has still to be achieved.
- We hypothesize that strength and position of the northhemispheric Westwind Circulation lead to the striking synchronicity between ocean overturning (MOC) and the terrestrial lacustrine system.
- Future work will concentrate on developing similar high resolution terrestrial records for paired lake studies and on partitioning the variance of different drivers for the climate development in Western Europe.

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