



## Quantifying the Northern Hemisphere Glaciation

**M. Mudelsee** (1,2), M.E. Raymo (3)

(1) Institute of Meteorology, University of Leipzig, Stephanstrasse 3, 04103 Leipzig, Germany (mudelsee@uni-leipzig.de), (2) Climate Risk Analysis – Manfred Mudelsee, Wasserweg 2, 06114 Halle (S), Germany (www.climate-risk-analysis.com), (3) Department of Earth Sciences, Boston University, 685 Commonwealth Avenue, Boston, MA 02215, USA (raymo@bu.edu)

The Northern Hemisphere Glaciation (NHG) in the Pliocene was a climatic change from a greenhouse world to a state with periodically waxing and waning ice sheets. Marine sedimentary records of ice-rafted debris and oxygen isotopic composition ( $\delta^{18}\text{O}$ ) reveal major glacial expansions 2.5 Myr and 2.7 Myr ago. Obstacles to a quantitative and causal understanding of the NHG are that  $\delta^{18}\text{O}$  reflects not only ice volume but also regional water temperature and that the NHG start (before about 3 Myr) has not yet been accurately estimated. We use 45  $\delta^{18}\text{O}$  records from benthic and planktonic foraminifera and globally distributed sites to reconstruct the dynamics of the NHG. We compare the  $\delta^{18}\text{O}$  amplitudes with those of temperature proxy records and estimate the global ice-volume related increase. By extracting the ice-volume signal from the data we find that the NHG started several hundred thousand years earlier than previously assumed, and ended at 2.4 Myr. This long-term increase points to slow, tectonic forcing such as closing of ocean gateways or mountain building, as the root cause of the NHG. We discuss a few of such mechanisms. We present geographical maps of deep and bottom water oceanic cooling across the NHG, estimate the increase in  $^{18}\text{O}$  variability across the NHG, show a new Pliocene biomagnetostratigraphic timescale and quantify the time constant of fluctuations in Northern Hemisphere ice mass.