Sudden ice sheet melt, changing ocean circulation & surface climate: Understanding the events of 14.6 ka

RUZA IVANOVIC[1*], LAUREN GREGOIRE[1],
ANDREW WICKERT[2] AND PAUL VALDES[3]

[1]Earth & Environment, University of Leeds, LS2 9JT, UK
(*correspondence: r.ivanovic@leeds.ac.uk)
[2]Earth & Env. Sciences, Universität Potsdam, Germany
[3]Geographical Sciences, University of Bristol, BS8 1SS, UK

Approximately 14.6 ka, global sea level rose by ~15 m in less than 350 years [1] during an event known as Meltwater Pulse 1a (MWP1a). Sea level records place MWP1a in a time of N. Hemisphere warmth, and modelling work [2] has suggested that around half of this ~50 mm yr-1 sea level rise came from the collapse of North American ice sheets. However, dating uncertainties make it difficult to determine the sequence of events and their drivers, leaving many fundamental questions. For example, did the abrupt ice melting and subsequent ocean freshening have any detectable climatic impact, or were there no feedbacks? Was melting from the Northern Hemisphere ice sheets responsible for the Older-Dryas [3] or other cooling events? And how were all these signals linked to changes in Atlantic Ocean overturning circulation (e.g. [4])?

To address these questions, we integrate ice sheet, solid earth, drainage and climate modelling, with a main focus on examining the effects of freshwater inputs to the ocean. We route meltwater to the coasts using a high-resolution drainage calculation [5], and use these results to force the HadCM3 Ocean–Atmosphere–Vegetation general circulation model.

The climate model shows two intriguing results: (i) a strong response in Atlantic circulation leading to a global-scale bipolar climate anomaly with widespread northern cooling; (ii) local warming that acts as a positive feedback mechanism to North American ice melt, despite the wider Northern Hemispheric cooling.

These data are compared to geological archives of ocean circulation during the Bolling warming and the Older Dryas periods to evaluate different hypotheses for the link between MWP1a and climate change.

Finally, we present the implications of this study for the internationally coordinated initiatives to simulate the last deglaciation (21-9 ka) and to ‘forward model’ geochemical components of the Earth System.

[1] Deschamps et *al*. (2012) *Nature* **483**, 559–564. [2] Gregoire et *al*. (2012) *Nature* **487**, 219–222. [3] Menviel et *al*. (2010) *QSR* **30**, 9-10. [4] Roberts et *al*. (2010) *Science* **327**, 75–78. [5] Wickert et *al*. (2013) *Nature* **502**, 668–671.