

North Atlantic Climate in the Ice-Age: Physics of the Dansgaard-Oeschger Oscillation

W. Richard Peltier, Department of Physics, University of Toronto

During Marine isotope Stage 3 of the last glacial cycle, North Atlantic climate recorded in Greenland Summit oxygen isotopic records, was characterized by intense millenium timescale oscillations. Originally discovered by Willi Dansgaard and Hans Oeschger based upon isotopic data from the GRIP ice core, each of these oscillations is characterized by a fast timescale transition from cold stadial to warm interstadial conditions and a much slower timescale return to the stadial state. Each pulse is therefor of "relaxation oscillation" form. These oscillations are apparently caused by a preceding "Heinrich event" instability of the ice stream that filled Hudson Strait under glacial conditions. The physical mechanism underlying the D-O mode of climate variability was originally suggested by Broecker (1994) to involve the exchange of fresh water between the oceans and grounded ice sheets on the continents. Under cold conditions it was imagined that fresh water would continue to accumulate as snow cover on northern hemisphere continental ice sheets, whereas under warm conditions land ice would melt thereby returning freshwater to the oceans, primarily the North Atlantic, thereby causing the meridional overturning circulation to diminish in strength, thereby leading to northern hemisphere cooling. In Peltier and Vettoretti (2014) it was shown that this mechanism was not fundamental to Dansgaard-Oeschger physics. This was achieved by showing that the D-O mode was recovered for the first time in the spin-up of a modern coupled atmosphere-ocean-sea ice model in which the boundary conditions were fixed on the basis of the University of Toronto ICE-6G_C (VM5a) model reconstruction of ice age paleotopography and paleobathymetry (Argus et al, 2014; Peltier et al, 2015). I have referred to this model-based reconstruction of the D-O oscillation as involving the action of a "kicked" salt oscillator in the Atlantic. The fact that a complex model of the kind employed to make projections of the global warming process is able to correctly capture such a complex physical process, in a region of parameter space that is well outside the region of this space in which it is tuned, represents a significant test of model quality.