

## **Millennial variability of ocean circulation and biogeochemical cycles during the last ice age**

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Millennial time-scale variability of ocean circulation during the last ice age was associated with some abrupt and large climate changes particularly in the North Atlantic. Ice-core data show that atmospheric CO<sub>2</sub> and other greenhouse gas concentrations co-varied on these time scales. Model simulations reveal the effect of large changes in the Atlantic Meridional Overturning Circulation on global cycling of nutrients, oxygen, and carbon in the ocean and the effects on atmospheric greenhouse gas concentrations. Gradual millennial changes in CO<sub>2</sub> can be understood by variations in the efficiency of the biological pump due to circulation changes. New high resolution ice-core data show abrupt CO<sub>2</sub> variations that are currently not understood.