Transient Changes in the Global Carbon Cycle During the Last Glacial/Interglacial Transition

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Abstract

The global carbon cycle plays a significant role in glacial/interglacial transitions. On one hand because carbon reservoirs and exchange rates are subject to external climate conditions, on the other because changes in pCO2 lead to amplification and mediation of regional climate variations. Time slice experiments were so far unable to unambiguously explain the driving forces of the glacial/interglacial pCO2 change of about 80 ppmv. Additional information can be derived from the temporal evolution of the carbon cycle using transient model runs tied to the carbon isotopic composition of CO2. Here, we use a coupled atmosphere/biosphere/ocean Box model of the isotopic Carbon cycle (BICYCLE) to quantify changes in pCO2 and δ13C in Antarctic ice cores. To this end the model is transiently driven by various proxy records over the last 26,000 years. The result shows that a breakdown in Southern Ocean (SO) stratification triggered by SO isotopic composition of CO2 might explain the initial drop in atmospheric δ13C. The result shows that a breakdown in Southern Ocean (SO) stratification triggered by SO isotope composition of CO2. Here, we use a coupled atmosphere/biosphere/ocean Box model of the Isotopic Carbon cycle (BICYCLE) to quantify changes in pCO2 and δ13C in Antarctic ice cores. To this end the model is transiently driven by various proxy records over the last 26,000 years. The result shows that a breakdown in Southern Ocean (SO) stratification triggered by SO isotope composition of CO2 might explain the initial drop in atmospheric δ13C by 0.5%/°. In addition, a significant role of the terrestrial biosphere on changes in δ13C during the second half of the transition is supported. Carbonate compensation has to be considered as additional process to explain the observed increase in pCO2.

Keywords: 1827 Glaciology, 4267 Paleoceanography, 4805 Biogeochemical Cycles

References

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Model

Structure of BICYCLE (Box model of the Isotopic Carbon cycle) adopted from Munhoven (1997) and Keshgi & Jain (2000). The internal module of the terrestrial biosphere or other model output of DGVMs can be used. Arrows indicate processes that change pCO2:

Processes pCO2
Temperature -29 ppmv
Sealevel +18 ppmv
Gas exchange +4 ppmv
Increased marine production -20 ppmv
Ocean circulation -69 ppmv
Terrestrial biosphere +26 ppmv
Carbonate compensation -18 ppmv

Sum of pCO2 changes -88 ppmv
Simulated pCO2 change -85 ppmv
Target -80 ppmv

Conclusions

1. Glacial/interglacial changes in sea ice might induce pCO2 changes not primarily via gas exchange (Stephens & Keeling, 2000) but via increased mixing in the SO. This can potentially explain the 0.5%/° drop in δ13C at the beginning of the termination.
2. Increased glacial marine export production via Fe fertilization depends on available macro-nutrients and thus oceanic transport processes.
3. SO processes as flywheel of THC kick-on (Knorr & Lohmann, 2003) are consistent with atmospheric carbon changes.
4. Dynamics in δ13C in the 2nd half of the transition are dominated by terrestrial biosphere growth.