Geophysical Research Abstracts
Vol. 12, EGU2010-12643, 2010
EGU General Assembly 2010

The role of ocean physics in setting glacial atmospheric CO2

Kevin Oliver (1), Simon Mueller (2), Neil Edwards (2), Gideon Henderson (3), and Ros Rickaby (3)

(1) National Oceanography Centre, University of Southampton, UK (K.Oliver@noc.soton.ac.uk), (2) Department of Earth and Environmental Sciences, The Open University, Milton Keynes, UK, (3) Department of Earth Sciences, University of Oxford, UK

The impact of ocean physics on atmospheric $p\mathrm{CO}_2$ is examined analytically and using ensembles experiments with the Earth system model GENIE. Results are interpreted in terms of the "red loop" (global low-mid-latitude upper and mode waters, and the Atlantic overturning cell), in which the efficiency of nutrient utilisation is high, and the "blue loop" (the Antarctic overturning cell) in which the efficiency of nutrient utilisation is low. For fixed efficiency of the red loop, atmospheric $p\mathrm{CO}_2$ can be lowered by decreasing ventilation of the blue loop, increasing ventilation of the red loop, increasing mixing between the red and blue loops, or decreasing particle flux from the red loop to the blue loop. This is because any of these changes increase *the fraction of nutrients in the global ocean that was last at the surface in the red loop, rather than the blue loop*. GENIE experiments yield an ambiguous response to increasing red loop ventilation rates, however, because the efficiency of this loop decreases in response to increased ventilation rates.

These findings are used, in conjunction with geochemical proxy simulations in the GENIE ensemble, to illuminate hypothesised mechanisms of glacial $p\mathrm{CO}_2$ cycles. A variety of mechanisms can produce δ^{13}C distributions comparable to last glacial maximum (LGM) observations, and this is associated with a decrease in $p\mathrm{CO}_2$ if the cause is the formation of high salinity, high density water in the Southern Ocean. This results in a highly stratified ocean and a contraction of the red loop. Nevertheless, the strong LGM meridional density gradients suggested by pore water salinity measurements are only sustained if there is plentiful energy for diapycnal mixing. This increases mixing between the red and blue loops, and can reconcile low atmospheric $p\mathrm{CO}_2$ with the absence of an exceptionally old water mass in the deep ocean.