Geophysical Research Abstracts, Vol. 7, 10249, 2005
SRef-ID: 1607-7962/gra/EGU05-A-10249

The combined impact of changing terrestrial organic carbon reservoirs and fractionation effects induced by changing carbonate ion concentrations on the glacial-interglacial marine C-13 record

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On the basis of the marine and atmospheric glacial-interglacial ^{13}C isotopic records, it has been calculated that the land biospheric carbon stock must have increased by 270–720 GtC from the Last Glacial Maximum (LGM) to the present. Estimates derived from vegetation mapping based on palynological or sedimentological data generally indicate a larger increase of the biospheric stock in the range of 700–1350 GtC and above. Although there is some overlap between the two ranges, they substantially disagree.

Further complications arise when carbonate-ion dependent fractionation effects in the marine ^{13}C record are considered. A detailed budget of the ^{13}C isotope in the land biosphere at the LGM, as well as in the other reservoirs of the global carbon cycle is therefore required. Here, we analyse the response of the atmosphere–ocean–surface-sediment system under the influence of variable release and uptake fluxes of C by the terrestrial biosphere. Glacial-interglacial variations of the carbon stocks and isotopic budgets of the land biosphere were derived from simulation experiments carried out with the global biosphere model CARAIB (CARbon Assimilation In the Biosphere) under boundary conditions typical for the Last Glacial Maximum and for mid-Holocene times. CARAIB uses a mechanistic description of both C_3 and C_4 photosynthetic pathways. It thus provides information on the ^{13}C signature of carbon fluxes involved. Using the eleven-box model MBM of the ocean-atmosphere system, we then investigate the effect of these biospheric changes on the oceanic carbon cycle and the CO_2 concentration in the atmosphere. MBM has a complete representation of the transfer processes of carbon and alkalinity from the land to the ocean, and between the ocean and the surface sediment, including parameterisations for processes in the shelf area. MBM also considers ^{13}C signatures of the carbon fluxes and stocks represented. On the basis of empirical relationships for the incorporation of ^{13}C isotopes in foraminiferal shells as a function of carbonate ion concentration, synthetic carbon isotopic records are generated from the calculated seawater ^{13}C isotopic evolution, helping to better constrain estimates of the land biosphere carbon stock changes derived from the marine ^{13}C record. These simulations also test various scenarios for the alkalinity input to the system from weathering, which, through their effect on carbonate ion concentration, may also impinge to a non negligible extent on ^{13}C variations recorded in deep-sea sediments.