Geophysical Research Abstracts,
Vol. 11, EGU2009-4836-1, 2009
EGU General Assembly 2009


# Carbon Isotopes in an Earth System Model

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We present first calculations of the carbon isotopic composition of carbon dioxide in the *Earth System Model* (ESM) COSMOS.

Earth System models consist of coupled models of the ocean, the atmosphere, the land surface, the biosphere (marine and terrestrial, plants and soils), and the cryosphere (snow and ice). In COSMOS from the Max Planck Institute for Meteorology, Hamburg, Germany, these components are the model of the atmospheric circulation ECHAM, the physical ocean model MPI-OM, the land surface parameterisation JSBACH and the oceanic carbon cycle model HAMOCC. The ESM COSMOS therefore calculates its own climate and $CO_2$ concentrations during the diel course with a few degrees resolution, driven only by solar activity and human perturbations.

The new model version now computes the multiple fractionation processes occurring during uptake of $CO_2$ from the atmosphere by the terrestrial and marine biosphere. The model then redistributes the isotopic compositions in the land and ocean biospheres, including respiration, phenology, fire, land-use change and carbon export. This means that it includes a full isotopic carbon cycle, in the atmosphere, the ocean and on land. The model calculates not only the stable carbon isotope signatures but also radiocarbon activities in the Earth System. It will include in future the radiocarbon perturbation due to nuclear bomb tests.

We compare first results of the ESM with other global estimates of terrestrial discrimination. We also compare predicted zonal and seasonal variations of isotope ratios in atmospheric $CO_2$ with measurements from the GLOBALVIEW flask network.

The stable and radioactive carbon isotopes are excellent tests for the overall model performance but also for individual model components. For example radiocarbon will be used to test stratosphere-troposphere exchange, ocean circulation and air-sea gas exchange.

The isotope-enabled model can be used in future for example to predict carbon isotope ratios of terrestrial plants, globally. It can track the changes in atmospheric compositions due to land use changes; for example the conversion of $C_3$ ecosystems to $C_4$ cultivation during the last century. But it can also track carbon isotope changes observed during the little ice age, as recorded in ice cores, and attribute them to land and ocean processes, and more specifically to climate or anthropogenic contributions.