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Carbon cycling of Lake Kivu (East Africa): net autotrophy in the epilimnion and emission of CO_2 to the atmosphere sustained by geogenic inputs

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We report organic and inorganic carbon distributions and fluxes in Lake Kivu, acquired during four field surveys, that capture the seasonal variations (March 2007 - mid rainy season, September 2007 - late dry season, June 2008 - early dry season, and April 2009 - late rainy season). The partial pressure of CO_2 (pCO_2) in pelagic surface waters of the main basin of Lake Kivu showed modest spatial variations (coefficient of variation between 3% and 6%), and modest seasonal variations with an amplitude of 163 ppm (between 579±23 ppm on average in March 2007 and 742±28 ppm on average in September 2007). The most prominent spatial feature of the pCO_2 distribution was the very high pCO_2 values in Kabuno Bay (a small sub-basin with little connection to the main lake) ranging between 11213 ppm and 14213 ppm (between 18 and 26 times higher than in the main basin). Surface waters of the main basin of Lake Kivu were a net source of CO_2 to the atmosphere at an average rate of 5.9 mmol m^{-2} d^{-1} which is lower than the global average reported for freshwater, saline and volcanic lakes. In Kabuno Bay, the CO_2 emission to the atmosphere was on average 274.8 mmol m^{-2} d^{-1} (∼46 times higher than in the main basin). Based on dissolved inorganic carbon (DIC) whole-lake mass balance of bulk concentrations and of stable isotope data, we show that the epilimnion of Lake Kivu was net autotrophic. This is due to the modest river inputs of organic carbon owing to the small ratio of catchment area to lake surface area (2.15). Our C bugdet implies that the CO_2 emission to the atmosphere must be sustained by DIC inputs of geogenic origin from deep geothermal springs. Based on metabolic rate measurements and mass balance considerations, we show that bacterial respiration was not solely sustained by particulate primary production, but also by dissolved primary production.