Boundaries of life: estimating the life span of the biosphere

S. Franck, C. Bounama and W. von Bloh

Potsdam Institute for Climate Impact Research, (franck@pik-potsdam.de/fax: +493312882570

We present a minimal model for the global carbon cycle of the Earth containing the reservoirs mantle, ocean floor, continental crust, continental biosphere, and the Kerogen, as well as the aggregated reservoir ocean and atmosphere and obtain reasonable values for the present distribution of carbon in the surface reservoirs of the Earth The Earth system model for the long-term carbon cycle is specified by introducing three different types of biosphere: prokaryotes, eucaryotes, and complex multicellular life. They are characterized by different global temperature tolerance windows: prokaryotes [2°C, 100°C], eucaryotes [5°C, 45°C], complex multicellular life [0°C, 30°C]. From the Archaean to the future there always exists a prokaryotic biosphere. 2 Gyr ago eucaryotic life first appears because the global surface temperature reaches the tolerance window for eucaryotes. The emergence of complex multicellular life is connected with an explosive increase in biomass and a strong decrease in Cambrian global surface temperature at about 0.54 Gyr ago. In the long-term future the three types of biosphere will die out in reverse sequence of their appearance. For realistic values of the biotic enhancement of weathering there is no bistability in the future solutions for complex life. Therefore, complex organisms will not extinct by an implosion (in comparison to the Cambrian explosion). Eucaryotes and complex life become extinct because of too high surface temperatures in the future. The ultimate life span of the biosphere is defined by the extinction of procaryotes in about 1.6 Gyr because of CO2 starvation. Only in a small fraction (1.3 Gyr) of its habitability time (6.2 Gyr) our home planet can harbour advanced life forms.