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Qualitative properties of the minimal model of carbon circulation in the biosphere

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Substantial changes in the biosphere during recent decades have caused legitimate concern in the international community. The fact that feedbacks between the atmospheric CO_2 concentration, global temperature, permafrost, ocean CO_2 concentration and air humidity increases the risk of catastrophic phenomena on the planetary scale. The precautionary principle allows us to consider greenhouse effect using the mathematical models of the biosphere–climate system. Minimal models do not allow us to make a quantitative description of the "biosphere–climate" system dynamics, which is determined by the aggregate effect of the set of known climatic and biosphere processes. However, the study of such models makes it possible to understand the qualitative mechanisms of biosphere processes and to evaluate their possible consequences.
The global minimal model of long-term dynamics of carbon in biosphere is considered basing on assumption that anthropogenous carbon emissions in atmosphere are absent [1]. Qualitative analysis of the model shows that there exists a set of model parameters (taken from the current estimation ranges), such that the system becomes unstable. It is also shown that external influences on the carbon circulation can lead either to degradation of the biosphere or to global temperature change [2]. This work is aimed at revealing the conditions under which the biosphere model can become unstable, which can result in catastrophic changes in the Earth's biogeocenoses. The minimal model of the biosphere-climate system describes an improbable, but, nevertheless, a possible worst-case scenario of the biosphere evolution takes into consideration only the most dangerous biosphere mechanisms and ignores some climate feedbacks (such as transpiration). This work demonstrates the possibility of implementing the trigger mode in the biosphere, which can lead to dramatic changes in the state of the biosphere even without additional burning of fossil fuels. This mode implementation is possible under parameter values of the biosphere, lying within the ranges of their existing estimates. Hence a potential hazard of any drastic change of the biosphere conditions that may speed up possible shift of the biosphere to a new stable state.

References

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