Geophysical Research Abstracts,
Vol. 11, EGU2009-11136-3, 2009
EGU General Assembly 2009

Dynamics of global carbon and water cycles under the climate change by a set of closed coupled models

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In order to study impact of climate change on the Earth biogeochemical cycles functioning a set of zero-dimensional closed models of combined global carbon and water cycles is suggested. Each model consists of three to seven reservoirs and matter flows between them. Any flow connecting two reservoirs depends only on storages in them either linearly, or in a bi-linear Volterra way, or as a function with saturation. Flow functions are calibrated by use of modern and pre-industrial "storage-flow" schemes either as a result of direct calculations, or by means of measured or estimated differences between vice versa fluxes for functions with saturation. Total amounts of carbon and water as well as the rates of anthropogenic emissions and land-use to the atmosphere are used as bifurcation parameters. In low-dimensional systems relative to the total system mass carbon storage of the atmospheric reservoir serves as a single fast variable and provides one-dimensional fast dynamics: slow motions is followed by a fast transition from one side of the slow manifold to another. The pre-industrial carbon balance is shown to be stable for the slow dynamic system while equilibrium of water cycle is unstable. Embedding of equation for the simplest climatic factor – the globally averaged annual temperature of the surface - and linking it with main intercompartment flows modify the model and allow one to obtain climate-induced boundaries of stability domains in the parameter space for possible equilibria of combined carbon and water cycle: hot desert, cold desert, different biospheric states. In five-compartment model where carbon of biota and soils is separated, anthropogenic emission growth can lead to the "catastrophic" equilibrium without terrestrial carbon that is removed through the atmosphere into oceans during several hundreds of years. The sequence of models with seven and eight reservoirs have more than one fast variables and allows one to study roles of surface and deep ocean and ocean biota in dynamics of the global carbon cycle. Temperature variation in accordance with different climatic scenarios generated by some climatic models and based on A2 and B1 carbon emission scenarios by IPCC as well as human perturbations trend initiates the transition scheme from one stable attractor to another thus simulating probable tendencies in functioning of coupled climatic and biotic machines on the Earth.

This work is supported by the program of the Earth Sciences Department of the Russian Academy of Sciences "Physical and chemical processes in atmosphere and on Earth surface determining climate change".