Geophysical Research Abstracts
Vol. 13, EGU2011-14170, 2011
EGU General Assembly 2011
© Author(s) 2011

# Towards Generalized Milankovitch Theory (Milutin Milankovic Medal Lecture)

Andrey Ganopolski
Potsdam Institute for Climate Impact Research, Potsdam, Germany

Although it is generally accepted that, as postulated by the Milankovitch theory, Earth's orbital variations play an important role in forcing glacial cycles, understanding of their nature still remains elusive. One of the major challenges for classical Milankovitch theory is the explanation of the 100 kyr cyclicity that has dominated global ice volume and climate variability over the past million years. This periodicity is absent in the Milankovitch forcing: variations of summer insolation at high latitudes of the Northern Hemisphere. The eccentricity of the Earth's orbit does contain periodicity close to 100 kyr, but the direct effect of the eccentricity variations on the global Earth's energy balance is small. In a view of this long-standing problem, a number of alternative or complimentary mechanisms have been proposed in recent decades to explain the 100 kyr cyclicity of the glacial cycles. Since the number of hypotheses is growing steadily, it became increasingly clear that the problem could not be resolved without the use of comprehensive Earth system models that account for the major processes and feedbacks in the system. Such a model, CLIMBER-2, was developed in Potsdam and is the principal tool for my analysis. The CLIMBER-2 model incorporates a 3-dimensional ice sheet model and a closed carbon cycle model. The results obtained with this model strongly suggest the necessity for "generalization" of the classical Milankovitch theory. The basic postulates of the Generalized Milankovitch theory can be formulated as following: (i) the glacial cycles represent a direct, strongly nonlinear response of the climate-cryosphere system to the orbital forcing; (ii) the strong 100 kyr cyclicity of ice volume variations originates from phase locking of the "long" glacial cycles to the eccentricity variations with 100 kyr periodicity. (iii) the existence of "long" glacial cycles requires a relatively low $CO_2$ level and large areas of the Northern Hemisphere continents to be clear of thick layers of terrestrial sediments. Physically, the link between glacial cycles and eccentricity is explained by the fact that the ice sheets tend to grow monotonously during periods of low eccentricity and reach their critical size (volume) soon after the minimum of eccentricity. When eccentricity starts to grow, the first strong positive excursion of Milankovitch forcing leads to the rapid and irreversible meltback of the Northern Hemisphere ice sheets. The lowering of snow and ice albedos by the deposition of aeolian dust plays an important role in glacial termination as well. At the same time, the $CO_2$ concentration not only determines the regime of glacial variability, but also strongly amplifies 100 kyr cycles. Therefore, simulation and understanding of the glacial cycles require the use of comprehensive Earth system models that include both physical and bio-geochemical components of the system.