Geophysical Research Abstracts,
Vol. 10, EGU2008-A-09962, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-09962
EGU General Assembly 2008

Feedback between climate and ocean methane hydrates in greenhouse climate

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Ocean methane hydrate reservoir is considered essentially irreversible tipping point in the Earth System. We included an improved version of methane hydrate model by Buffett and Archer [2004] into climate model of intermediate complexity, CLIMBER-2, to investigate a feedback between methane hydrates and climate change. For pre-industrial climate, the model simulates about 2,000 GtC of methane in form of hydrates and bubbles trapped in the sediments beneath the ocean floor. Most of this methane storage is in the Pacific, in large part because lower oxygen levels in the Pacific enhance the preservation of organic carbon to reach the methanogenesis zone. However, because the oxygen concentrations today may be different from the long-term average, we regard the model sensitivity to O_2 to be an indication of uncertainty. Both the Arctic and the Antarctic hold significant amounts of methane, due entirely to the colder temperatures in the high-latitude water column.

The interactive climate-carbon cycle model was driven by several scenarios of anthropogenic CO_2 emissions. Atmospheric CO_2 concentration and climate were calculated interactively for the next 10,000 years. Because radiative forcing of methane is much stronger than the forcing of carbon dioxide, we explored different assumptions about a fraction of methane which can avoid oxidation in the water column and enter the atmosphere.

Accounting for methane hydrate response results in substantial amplification of CO_2 and temperature growth, which accelerates deep ocean warming and leads to further

destabilization of the hydrate reservoir. This feedback puts additional constrain on permissible fossil fuel emissions in case of climate stabilization target.

Buffett, B., and Archer D., 2004, Global inventory of methane clathrate: sensitivity to changes in the deep ocean, *Earth and Planetary Science Letters*, **227**, 185-199.