Geophysical Research Abstracts,
Vol. 11, EGU2009-5500-1, 2009
EGU General Assembly 2009

Modelling uncertainties in the climate of the last millennium: the ASTER project

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The LOVECLIM model (Driesschaert et al., 2007; Goosse et al., 2007) is used to simulate the climate of the last millennium with several 'climate' parameter sets yielding different sensitivities of the climate and the carbon cycle model. The purpose of these simulations is twofold. We intend to assess first the role of the carbon cycle on the climate, and second, the ability of the different selected parameter sets to drive the model within the range of the observed climate, and further to assess the uncertainty related to these parameters. The high frequency variability of the forcings is taken into account. For each set of parameters, LOVECLIM is driven by the natural evolution of insolation, solar irradiance and stratospheric aerosol concentrations due to volcanic activity as well as by changes caused by human activities such as deforestation, CO2 emission or concentration changes, changes in concentrations of greenhouse gases other than CO2 (including ozone) and in sulphate aerosol load.

Several transient experiments are conducted for each parameter set. A first transient simulation (Conc) is forced with reconstructed atmospheric CO2 concentration. In the next two simulations, the emissions of carbon were taken into account, the model computing the corresponding atmospheric CO2 concentration. First (EMIS), the emissions due both to the land use changes and the fossil fuel burning are provided. Second (Efor), only the emissions from fossil fuel burning are provided in addition to the vegetation change related to deforestation.

The Northern Hemisphere annual mean temperatures simulated by the model according to the different parameter sets and carbon cycle sensitivities and the different experimental setups do not show striking differences compared to the NH temperature recontructions (IPCC, 2007). However, the simulated values are generally in the lower range of the reconstructions in the interval 900-1200 AD. Moreover some experiments are displaying a too large warming during the last century as well as a large variability occasionally out of the range of observation. The increase in atmospheric CO2 concentration over the last century is strongly depending on how the anthropogenic emission and the land-use scenario are taken into account. Difference in atmospheric CO2 concentration can reach up to 50 ppmv.

All the parameter sets are not able to reproduce the decreasing trend of the Arctic summer sea ice as recorded over the last decades. Parameter sets corresponding to the largest climate sensitivity lead to a strong reduction of the summer sea ice. However, different scenarios for deforestation lead to significantly different time evolution of the NH Summer sea ice area for the same parameter set.

The ocean C storage remains within the range of estimates when CO2 is prescribed. However, values are much larger when both fossil fuel and land cover change emission are prescribed. The deforestation emissions as computed by the model lead to intermediate cumulative CO2 fluxes to the atmosphere.

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