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SCIENCE FOR A SUSTAINABLE DEVELOPMENT

Assessment of Modelling Uncertainties in Long-Term Climate and Sea Level Change Projections

« ASTER »

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SD/CS/01A

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ASSESSMENT OF MODELLING UNCERTAINTIES IN LONG-TERM CLIMATE AND SEA LEVEL CHANGE PROJECTIONS. (ASTER – PHASE I)

Contract SD/CS/01A

A number of improvements have been made to LOVECLIM, the Earth climate model of intermediate complexity used in the ASTER project. This model consists of five components representing the atmosphere, the ocean and sea ice, the terrestrial biosphere, the oceanic carbon cycle and the Greenland and Antarctic ice sheets. The land surface scheme has been improved to better take into account the impact of the vegetation on the evaporation and bucket depth. The coupling between the ocean-sea ice model and the oceanic carbon cycle module (LOCH) has been revised to guarantee the coherency between the transports of biogeochemical tracers and salinity. The biological module of LOCH has also been adapted. Development work on the ice sheet model has concentrated on additionally incorporating a Northern Hemisphere ice sheet model into LOVECLIM. An important part of the ASTER work was also devoted to the selection of parameter sets that lead to different responses of LOVECLIM to external forcings but still guarantee that the climate simulated for present-day conditions remains close to the observed one. Nine parameter sets were selected, which lead to different climate sensitivities (response to a $2{\times}CO_2$) from 1.5°C to 4.0°C and to different reduction of the meridional ocean circulation in response to a freshwater perturbation in the North Atlantic. Similarly, three parameter sets were identified in LOCH that have potentially low, medium and high impacts on the atmospheric CO_2 concentration. Finally, three parameter sets were chosen that control the sensitivity of the ice sheets to warming. The improved version of the climate model together with the selected parameter sets allow evidencing a strong relationship between the simulated decrease in summer sea-ice extent in the future and for 8 kyr BP. In other words, if these results are further confirmed, an accurate knowledge of the summer sea ice extent at 8 kyr BP would give a better confidence in the prediction of future evolution of the summer sea-ice extent. The possible irreversibility of a disappearance of the Greenland ice sheet in a warming climate was also tested in a series of experiments. According to these experiments, a completely melted away Greenland ice sheet cannot regrow (or very slowly). Only a drastic reduction in atmospheric CO_2 concentration is able to interrupt the melting process but, even in that case, the ice sheet does not regrow. The climate of the last millennium was also simulated with nine 'climatic' parameter sets. The modelled global climatic features are in relatively good agreement with observations. A more detailed analysis of the model results at the regional scale must still be performed.

Those experiments lead to reasonable estimates of the carbon fluxes between reservoirs. At this stage, the available datasets do not allow clearly identifying some climate parameter sets as more or less appropriate than others. Several sets yield however major changes in the carbon response when the model is perturbed by a freshwater flux in the North Atlantic. The ventilation rate of the deep ocean seems to be determinant in setting the atmospheric CO_2 levels in the various sensitivity experiments that were performed.