Geophysical Research Abstracts
Vol. 14, EGU2012-3747, 2012
EGU General Assembly 2012
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Stable Water Isotopes in a Coupled Atmosphere-Vegetation Model: Sensitivity Studies for Present Day Conditions

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In this study we present first results of a new model development, called ECHAM5j-wiso, where we have incorporated the stable water isotopes $H_2^{18}O$ and HDO as tracers in the hydrological cycle of the coupled atmosphere – land surface model ECHAM5-JSBACH. The JSBACH component is a state-of-the-art land surface model, which includes for example dynamical vegetation, carbon cycle and photosynthesis. Incorporation of stable water isotopes into JSBACH allows the explicit simulation and analyses of isotope fluxes and relevant fractionation processes both for evaporation (from bare soil) as well as from transpiration (water transport through plants).

In order to analyse the performance of our new model set up we compare several simulations with various implementations of water isotope fractionation processes over land surface. The simulations allow us to distinguish between no fractionation at all, fractionation included in the evaporation flux (from bare soil) and also fractionation included in both evaporation and transpiration (from water transport through plants) fluxes. All simulations were run under present-day climate conditions in a T31L19 model resolution.

The comparison between ECHAM5-wiso and ECHAM5j-wiso (for the case of no isotope fractionation over land surfaces) shows, that the δ18O (δD) of precipitation varies approx between -1‰ (-9‰) to +1‰ (+8‰); the clearest difference takes place at the mid latitudes in the northern hemisphere as well as in Antarctica. A comparison of the simulated surface temperature shows, that at these areas the temperature also varies up to +/- 2.2 C°. A closer look at the different ECHAM5j-wiso simulations using full or no fractionation during evaporation over land surfaces shows a variation of δ18O (δD) between -1‰ (-11‰) up to +4‰ (+40‰) for the isotopic composition of precipitation. Over land surfaces, a general enrichment of δ18O (δD) in precipitation is simulated. Highest differences in δ18O and δD in precipitation between the simulations are detected at those regions where the isotopic signature of the soil water reservoir significantly differs, too, for example over South Africa.