International Max Planck Research School on Earth System Modelling

# Vegetation - albedo - precipitation interactions in North Africa during the Holocene


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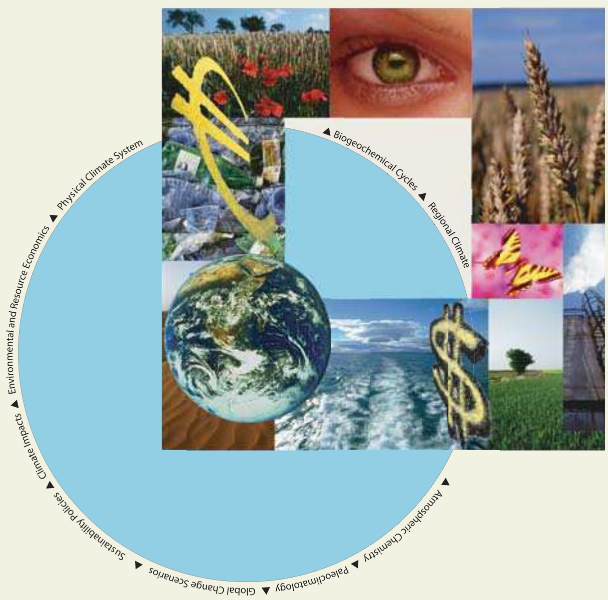

## Abstract

A new land surface albedo scheme that takes the dynamic behaviour of the surface below the canopy into account, has been implemented into the land surface scheme of the Earth system model of the Max Planck Institute for Meteorology (MPI-ESM). The standard scheme calculates the seasonal canopy albedo as a function of leaf area index, whereas the background albedo is a gridbox constant derived from satellite measurements. The new scheme additionally models the background albedo as a slowly changing function of organic matter in the ground, and of litter and standing dead biomass covering the ground.

The new albedo scheme was developed to investigate the large climatic change between the present-day and the mid-Holocene, during which the Sahara was substantially wetter than today. Using different model setups of the MPI-ESM: a land surface with and without dynamic vegetation, and with and without the new albedo scheme, the interactions between vegetation, albedo and precipitation in the Sahel/Sahara on multiple timescales from multi-millennia to interannual are investigated.

The correspondence between annual mean albedo and vegetation seen in observations is well-captured with both albedo schemes in the pre-industrial simulations, but it is only captured with the dynamic scheme for the mid-Holocene. The dynamic scheme thus gives a better estimate of albedo change than the static scheme. With the introduction of the new scheme, precipitation in the Sahel/Sahara and the Arabian Peninsula is increased by 30 mm/year for the pre-industrial simulation and by about 80 mm/year for the mid-Holocene simulation. The sensitivity of regional precipitation to external forcing is thus increased by about one third.

The simulated desert border is shifted by at least 300 km in the mid-Holocene. The new scheme leads to increased vegetation variability in the remaining desert region during the mid-Holocene, indicating a higher frequency of green spells. The suitability of the simulated mean climate as the measure to compare with mid-Holocene palaeo-records is discussed. Due to spatial sparsity and low time resolution of vegetation proxies it might be more appropriate to consider vegetation variability or desert stability rather than the mean.

The interactions between vegetation, albedo and precipitation at sub-centennial timescales are also examined. It is found that by introducing dynamic vegetation,

the amplitude of rainfall anomalies is increased, due to an amplification at short timescales. The new albedo scheme acts as filter on precipitation variability, which reduces interannual variability and increases long-term persistence.

The results presented in this thesis highlight the importance of both dynamic vegetation and albedo schemes for the simulation of plausible precipitation dynamics at all timescales in the Sahel/Sahara region.