Modelling Ecosystems, Biosphere-Atmosphere Interactions and Environmental Change with LPJ-GUESS

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Introduction

LPJ-GUESS [1] is a dynamic vegetation model (DVM) optimised for regional to global applications. It simulates many processes which occur in the terrestrial biosphere including photosynthesis; plant growth, competition, establishment and mortality; hydrological processes and the carbon and nitrogen dynamics.

Methods

At the Biodiversität und Klima Forschungzentrum (BiK-F) and with the aid of Hessen HPC facilities, we apply LPJ-GUESS over a variety of regions and time periods to investigate research topics in the areas of ecology, environmental change and interactions between the atmosphere and terrestrial biosphere. An example of a global-scale study is a recent publication in which we compared simulated forest mortality from a LPJ-GUESS with reported drought-related mortality events from literature [2].

Results

The major conclusions we drew from our results were: 1.) Already dry forests were more vulnerable to drought, whereas forests in wet climates often benefited from warmer (drier) conditions; 2.) The current implementation of mortality in the model is still insufficient and requires a better process description to capture observed mortality incidents 3.) We postulate that heat and/or drought might not be the primary driver for all reported mortality events.

In a high-resolution, regional study of Turkey, LPJ-GUESS was used to investigate future changes to vegetation (in particular productivity) under climate change scenarios [3]. After adapting the vegetation parameters to better represent Turkish vegetation and then benchmarking against satellite data and expert maps, the model was used prognostically with future climate data from a regional climate model. The results showed that in some areas of Turkey productivity increased due to warmer temperatures during the spring growing season. In other areas decreases in precipitation and extremely high temperatures reduced productivity.

Herbivores are considered to be an important driver in vegetation dynamics yet there is no consensus about the quantity of the grazer impact on the vegetation. To further promote the insight into herbivore-vegetation interaction and ecology, we coupled LPJ-GUESS with a modern grazer model [4]. The coupled model enabled us to estimate grazer population densities in African savannahs [5] and over the whole African continent and allowed us to indicate grazer population drivers, which seem to differ on the savanna and the continental scale [6]. Further efforts are made to implement a dynamic predator model and future applications of the model may be to estimate future distributions of grazers in regard of climate change or to evaluate the human and climatic impact on the megafauna extinction in the Late Pleistocene (approximately 126,000 to 9700 year before present).

Outlook

Other ongoing projects also illustrate the wide range of application of the LPJ-GUESS model. In one study LPJGUESS is being used to investigate global vegetation patterns in the Late Miocene period (7-12 million years before present) and the results are compared to plant fossils. Another study involves simulating wildfire in tropical biomes examining its effects on tropical biomass. We are also undertaking a collaboration with the MaxPlank Instutite for Atmospheric Chemistry in Mainz and the University of Mainz in which we are coupling LPJGUESS to atmospheric chemistry and circulation model to better understand the bilateral interactions between the biosphere and the atmosphere.

Reference

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