Geophysical Research Abstracts
Vol. 13, EGU2011-8028, 2011
EGU General Assembly 2011

The role of plant functional trade-offs for tropical biodiversity changes and biome shifts under scenarios of global climatic change

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Species-specific physiological tolerances to climatic constraints determine the global geographic distribution of biodiversity and biomes. Under global climatic change high latitudes climates are expected to become warmer and thus less constraining for plant growth. To the contrary, tropical climates are expected to become warmer and drier, which sets additional constraints to plant growth and survival. These increasing climatic constraints may affect tropical biodiversity and the extend of the tropical forest biome.

In this study, we use the Jena Diversity model (JeDi), a process-based vegetation model, which considers plant functional trade-offs and their interaction with climate, to predict the global geographic distribution of biodiversity and biomes under climatic change. JeDi simulates plant survival according to essential plant functional trade-offs, including eco-physiological processes such as water uptake, photosynthesis, allocation, reproduction and phenology. Due to this trade-off approach, the model does not rely on empirical parametrization to contemporary climate or vegetation distribution. We apply JeDi to quantify biodiversity changes and biome shifts between present-day and a range of possible future climates from two scenarios (A2 and B1) and seven global climate models using metrics of plant functional richness and functional identity.

We find under climatic change a significant loss of functional richness in the tropics. This result is in reasonable agreement with the result of an empirical study projecting biodiversity changes. We further are able to explain this loss in functional richness from trade-offs involved in the carbon allocation and eco-physiology of plants. However, we find biome changes in the tropics were relatively moderate, compared to biome changes at high latitudes. We explain this divergent response in terms of the effects of functional diversity. This result is in contrast to the results of the current generation of dynamic global vegetation models with a limited number of plant functional types, which predict for instance a rapid shift in the tropical forest biome due to climatic change associated with changes in the simulated plant carbon balance. Our results highlight thereby the importance of incorporating biodiversity into global vegetation modelling.