Geophysical Research Abstracts,
Vol. 11, EGU2009-13395, 2009
EGU General Assembly 2009

Constrained parameterisation of photosynthetic capacity causes significant increase of modelled tropical vegetation surface temperature

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Photosynthetic capacity is one of the most sensitive parameters of terrestrial biosphere models whose representation in global scale simulations has been severely hampered by a lack of systematic analyses using a sufficiently broad database. Due to its coupling to stomatal conductance changes in the parameterisation of photosynthetic capacity may potentially influence transpiration rates and vegetation surface temperature.

Here, we provide a constrained parameterisation of photosynthetic capacity for different plant functional types in the context of the photosynthesis model proposed by Farquhar et al. (1980), based on a comprehensive compilation of leaf photosynthesis rates and leaf nitrogen content. Mean values of photosynthetic capacity were implemented into the coupled climate-vegetation model ECHAM5/JSBACH and modelled gross primary production (GPP) is compared to a compilation of independent observations on stand scale.

Compared to the current standard parameterisation the root-mean-squared difference between modelled and observed GPP is substantially reduced for almost all PFTs by the new parameterisation of photosynthetic capacity. We find a systematic depression of NUE (photosynthetic capacity divided by leaf nitrogen content) on certain tropical soils that are known to be deficient in phosphorus. Photosynthetic capacity of tropical trees derived by this study is substantially lower than standard estimates currently used in terrestrial biosphere models. This causes a decrease of modelled GPP while it significantly increases modelled tropical vegetation surface temperatures, up to 0.8°C. These results emphasise the importance of a constrained parameterisation of photosynthetic capacity not only for the carbon cycle, but also for the climate system.