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Towards an improved representation of biogeochemical interactions at the vegetation-atmosphere interface: results from a dynamic vegetation model.

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The vegetation-atmosphere interface is an area of complex physical and biogeochemical interactions. A growing body of evidence indicates a variety of positive and negative biogeochemistry-related climate feedbacks at this interface, whose overall magnitude may be similar to those found in the physical climate system. Processes associated with these feedbacks include the potential rates of photosynthesis and respiration, nitrogen limits on photosynthetic carbon fixation, permafrost and wetland carbon emissions, ozone phytotoxicity, and the potential for plant emissions to mediate tropospheric ozone production and destruction. The level of understanding of these feedbacks and their impact on the Earth system is currently very low; the parameter space they occupy is complex and scarcely investigated. In particular, the heterogeneous distribution and non-linear behaviour of the key inputs is likely to lead to strong regional variations in climate forcing. Yet these processes are not just important for climate, they may profoundly impact both crop yields and natural ecosystem composition by affecting the viability of vegetation. Such changes in ecosystems may be relatively subtle, or catastrophic and irreversible (e.g. die-back of tropical or high-latitude forests) with wide-ranging environmental and societal consequences.

Dynamic vegetation models are a key tool for investigating these interactions, both for stand-alone simulations and as part of Earth System Models. The LPJ-GUESS dynamic global vegetation model (DGVM) has recently been greatly improved by the development of a process-based carbon-nitrogen cycling module, an improved description of biomass burning, addition of permafrost and wetland emissions and a representation of the effects of ozone phytotoxicity on plants. We will present simulation experiments that specifically investigate interactions between changes in climate and atmospheric CO_2 levels, global fire regime and emissions, and carbon and nitrogen cycling. The aim of this work is to assess the importance of the various biogeochemical-related processes for ecosystem productivity/composition and climate-relevant fluxes. The simulations will be performed under the auspices of the EMBRACE project (http://www.smhi.se/embrace).