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Process-based estimates of terrestrial ecosystem isoprene emissions: incorporating the effects of a direct CO_2-isoprene interaction

A. Arneth[1], Ü. Niinemets[2,3], S. Pressley[4], J. Bäck[5], P. Hari[5], T. Karl[6], S. Noe[2], I. C. Prentice[7], D. Serça[8], T. Hickler[1], A. Wolf[9], and B. Smith[1]

[1]Department of Physical Geography and Ecosystems Analysis, Geobiosphere Science Centre, Lund University, Sölvegatan 12, 223 62, Lund, Sweden
[2]Department of Plant Physiology, Institute of Molecular and Cell Biology, University of Tartu, Riia 23, Tartu 51010, Estonia
[3]Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Kreutzwaldi 64, Tartu 51014, Estonia
[4]Washington State University, Department of Civil and Environmental Engineering, USA
[5]Department of Forest Ecology, University of Helsinki, Finland
[6]Atmospheric Chemistry Division, National Center for Atmospheric Research, Boulder, Colorado, USA
[7]QUEST, Department of Earth Sciences, University of Bristol, Bristol BS8 1RJ, UK
[8]Laboratoire d'Aerologie, Toulouse, France
[9]Forest Ecology, ETH Zürich, Switzerland

Abstract. In recent years evidence has emerged that the amount of isoprene emitted from a leaf is affected by the CO_2 growth environment. Many – though not all – laboratory experiments indicate that emissions increase significantly at below-ambient CO_2 concentrations and decrease when concentrations are raised to above-ambient. A small number of process-based leaf isoprene emission models can reproduce this CO_2 stimulation and inhibition. These models are briefly reviewed, and their performance in standard conditions compared with each other and to an empirical algorithm. One of the models was judged particularly useful for incorporation into a dynamic vegetation model framework, LPJ-GUESS, yielding a tool that allows the interactive effects of climate and increasing CO_2 concentration on vegetation distribution, productivity, and leaf and ecosystem isoprene emissions to be explored. The coupled vegetation dynamics-isoprene model is described and used here in a mode particularly suited for the ecosystem scale, but it can be employed at the global level as well.

Annual and/or daily isoprene emissions simulated by the model were evaluated against flux measurements (or model estimates that had previously been evaluated with flux data) from a wide range of environments, and agreement between modelled and simulated values was generally good. By using a dynamic vegetation model, effects of canopy composition, disturbance history, or trends in CO_2 concentration can be assessed. We show here for five model test sites that the suggested CO_2-inhibition of leaf-isoprene metabolism can be large enough to offset increases in emissions due to CO_2-stimulation of vegetation productivity and leaf area growth. When effects of climate change are

considered atop the effects of atmospheric composition the interactions between the relevant processes will become even more complex. The CO_2-isoprene inhibition may have the potential to significantly dampen the expected steep increase of ecosystem isoprene emission in a future, warmer atmosphere with higher CO_2 levels; this effect raises important questions for projections of future atmospheric chemistry, and its connection to the terrestrial vegetation and carbon cycle.

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