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Geosci. Model Dev., 6, 1517-1542, 2013
www.geosci-model-dev.net/6/1517/2013/
doi:10.5194/gmd-6-1517-2013

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GAPPARD: a computationally efficient method of approximating gap-scale disturbance in vegetation models

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Received: 03 January 2013 – Published in Geosci. Model Dev. Discuss.: 15 February 2013
Revised: 16 July 2013 – Accepted: 17 July 2013 – Published: 12 September 2013

Abstract. Models of vegetation dynamics that are designed for application at spatial scales larger than individual forest gaps suffer from several limitations. Typically, either a population average approximation is used that results in unrealistic tree allometry and forest stand structure, or models have a high computational demand because they need to simulate both a series of age-based cohorts and a number of replicate patches to account for stochastic gap-scale disturbances. The detail required by the latter method increases the number of calculations by two to three orders of magnitude compared to the less realistic population average approach. In an effort to increase the efficiency of dynamic vegetation models without sacrificing realism, we developed a new method for simulating stand-replacing disturbances that is both accurate and faster than approaches that use replicate patches. The GAPPARD (approximating GAP model results with a Probabilistic Approach to account for stand Replacing Disturbances) method works by postprocessing the output of deterministic, undisturbed simulations of a cohort-based vegetation model by deriving the distribution of patch ages at any point in time on the basis of a disturbance probability. With this distribution, the expected value of any output variable can be calculated from the output values of the deterministic undisturbed run at the time corresponding to the patch age. To account for temporal changes in model forcing (e.g., as a result of climate change), GAPPARD performs a series of deterministic simulations and interpolates between the results in the postprocessing step. We integrated the GAPPARD method in the vegetation model LPJ-GUESS, and evaluated it in a series of simulations along an altitudinal transect of an inner-Alpine valley. We obtained results very similar to the output of the original LPJ-GUESS model that uses 100 replicate patches, but simulation time was reduced by approximately the factor 10. Our new method is therefore highly suited for rapidly approximating LPJ-GUESS results, and provides the opportunity for future studies over large spatial domains, allows easier parameterization of tree species, faster identification of areas of interesting simulation results, and comparisons with large-scale datasets and results of other forest models.

Citation: Scherstjanoi, M., Kaplan, J. O., Thürig, E., and Lischke, H.: GAPPARD: a computationally efficient method of approximating gap-scale disturbance in vegetation models, Geosci. Model Dev., 6, 1517-1542, doi:10.5194/gmd-6-1517-2013, 2013.