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# Modelling inter-PFT competition and fire in terrestrial ecosystem components of climate and earth system models

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The global distribution of vegetation and terrestrial ecosystem structure are determined by climate and the natural and anthropogenic disturbance regimes. Regions where bioclimatic parameters are favourable for several plant functional types (PFTs) the inter-PFT competition determines vegetation distribution. Disturbance, and in particular fire, plays a major role in modulating this inter-PFT competition. Many current dynamic global vegetation models (DGVMs) and terrestrial ecosystem components of climate/earth system models do not, however, explicitly simulate competition and determine vegetation distribution based on modifications of climate-vegetation equilibrium relationships. DGVMs that do explicitly simulate competition are based on versions of the Lotka-Volterra (LV) equations originally developed in the context of predator-prey competition, and which as a consequence may exhibit unrealistic behaviour in some situations. In particular, the use of the LV equations leads to unrealistic lack of coexistence of PFTs. A generalized approach for competition-colonization among plant functional types is proposed that overcomes some of the limitations of existing approaches and which includes the LV equations as a special case. The approach is tested for a range of climate and vegetation regimes (boreal forest, tropical forest, savanna, and temperate forest) within the framework of the Canadian Terrestrial Ecosystem Model (CTEM) and is able to reasonably simulate the observed mix of PFTs, suitable successional behaviour, and the observed equilibrium vegetation distribution.

Unlike most existing DGVMs, CTEM also explicitly simulates fire as a process-based climate-dependent process that modulates inter-PFT competition. The approach used

is simple, general enough to be applied globally and robust enough for transient climate change simulations. Specifically, it takes into account all three aspects of the fire triangle: fuel availability, readiness of fuel to burn depending on weather conditions, and the presence of an ignition source. The approach also takes into account the anthropogenic effect on natural fire regimes. The fire parameterization, which estimates burn area, is included in the Canadian Terrestrial Ecosystem Model (CTEM) that simulates net primary productivity, leaf area index, and vegetation biomass. Estimates of burn area and vegetation biomass are used to estimate CO2 emissions. Comparison of simulated fire return intervals and CO2 emissions with observation-based estimates for tropical savanna, tropical humid forests, and boreal forest locations indicate that the fire parameterization performs satisfactorily.