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Fire disturbance and land cover at high latitudes and the Arctic: model-data comparison and model modification

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Land cover, fire and biomass are intimately connected in determining the carbon balance of the high latitude land surface (polewards of 50N). Three current land surface models (LPJ-WM, CLM4CN, SDGVM) give comparable values of the Net Biome Production (NBP) for high latitudes and the Arctic, but this conceals sharp differences between how the models represent the component fluxes making up the NBP, particularly their estimates of emissions due to fire. Comparisons with satellite-based burnt area data from the Global Fire Emissions Database (GFED) indicate that all models fail to represent the observed spatial and temporal properties of the fire regime. Discrepancies between models and data are also found in the average annual burnt area and the GFED (model-based) fire emissions. Fire emissions are found to differ by a factor four between the models, because of fundamentally different approaches to the parameterization of fuel load and combustion processes for both above-ground biomass and litter.

A more realistic representation of the fire regime shows that, for northern high latitudes: i) fire years do not necessarily result in source years; ii) the inter-annual variability of fire emissions does not significantly affect the inter-annual variability of NBP; and iii) it is likely that current land models are unable to capture the links between permafrost and fire, because of their inadequate representations of fire occurrence properties.

In addition, use of different land cover data sets to constrain the models gives rise to variations of up to 20% in estimates of NBP and 50% in fire emissions; hence land cover data constitute a major source of uncertainty in quantifying high latitude carbon dynamics.