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Influences of temporal fuel variability on modelling fire occurrence and emissions

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Fires are a global phenomenon with diverse influences on vegetation distribution, biogeochemical cycles and physical properties of the Earth surface. Fires can occur given the availability of fuel, which needs to be sufficiently dry, and the presence of an ignition source. To estimate global carbon emissions from fires different methods are used to assess the availability and amount of fuel. There are static approaches based on the land cover type combined with a vegetation type dependent biomass density and dynamic approaches based on vegetation models. Static approaches cannot account for the seasonal or long term variation in fuels and can therefore not represent a temporal occurrence of fuel limitation or long term changes as they can be expected from CO_2 fertilization.
In this study we want to address the influence of seasonal fuel variability and the variability caused by changes in CO_2 concentration from preindustrial to 2005. We use a land surface model (JSBACH) including an implementation of the mechanistic fire model SPITFIRE. We perform a reference simulation with daily updated fuel load and simulations with the fuel load fixed to the mean fuel load, to maximum monthly fuel load and the minimum monthly fuel load of the reference. To study the influence of CO_2 fertilization on fire occurrence and emissions we compare a simulation with historical CO_2 increase and historical climate, with a simulation where we use constant preindustrial CO_2 for photosythesis.
The simulation using the mean fuel load shows similar results to the reference run. The simulations using minimum and maximum fuel show a large difference in global values (311 and 416 Mha burned globally, 2.25 and 2.67 Pg C emissions, respectively), but similar global distributions. Differences occur mainly in fuel limited regions. When establishing biomass density maps the seasonality should be considered, as the deviations between minimum and maximum fuel load within a year show a strong impact on the global sum. The influence on the seasonality differs between regions. The simulation with preindustrial CO_2 fertilization shows a reduction not only in carbon emissions but also in burned area compared to the historical simulation.
We conclude, that static approaches may perform reasonably for annual estimates under present day climate, but may show biases for projections to past or future when not considering the effect of CO_2 on the vegetation carbon pools.