Project: **1067**

Project title: **Fire-vegetation-climate interactions**

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Due to obligations for the analysis of older simulations within the fire model intercomparison project (FireMIP) I was not able to conduct the planned work and therefore did not use a large part of the computing time.

There was however considerable progress based on the analysis of old simulations performed in this project.

Response of simulated burned area to historical changes in environmental and anthropogenic factors

Understanding how fire regimes change over time is of major importance for understanding their future impact on the Earth system, including society. Large differences in simulated burned area between fire models show that there is substantial uncertainty associated with modelling global change impacts on fire regimes. We draw here on sensitivity simulations made by seven global dynamic vegetation models participating in the Fire Model Intercomparison Project (FireMIP) to understand how differences in models translate into differences in fire regime projections. The sensitivity experiments isolate the impact of the individual drivers on simulated burned area, which are prescribed in the simulations. Specifically these drivers are atmospheric CO_2 concentration, population density, land-use change, lightning and climate.

The seven models capture spatial patterns in burned area. However, they show considerable differences in the burned area trends since 1921. We analyse the trajectories of differences between the sensitivity and reference simulation to improve our understanding of what drives the global trends in burned area. Where it is possible, we linked the inter-model differences to model assumptions.

Overall, these analyses reveal that the largest uncertainties in simulating global historical burned area are related to the representation of anthropogenic ignitions and suppression and effects of land use on vegetation and fire. In line with previous studies this highlights the need to improve our understanding and model representation of the relationship between human activities and fire to improve our abilities to model fire within Earth system model applications. Only two models show a strong response to atmospheric CO_2 concentration. The effects of changes in atmospheric CO_2 concentration on fire are complex and quantitative information of how fuel loads and how flammability changes due to this factor is missing. The response to lightning on global scale is low. The response of burned area to climate is spatially heterogeneous and has a strong inter-annual variation. Climate is therefore likely more important than the other factors for short-term variations and extremes in burned area. This study provides a basis to understand the uncertainties in global fire modelling. Both improvements in process understanding and observational constraints reduce uncertainties in modelling burned area trends.

Fire and ecosystems: Fire-induced tree cover and carbon storage reduction

We used simulations from seven Dynamic Global Vegetation Models to provide the first multi-model estimate of fire impacts on global tree cover and the carbon cycle under current climate and anthropogenic land use conditions, averaged for the years 2001-2010.

The model ensemble mean shows a 10% decrease in global tree cover and vegetation carbon due to fire. Regionally the effects are much stronger, up to 20% for certain latitudinal bands. Our estimates are lower compared to previous studies, which we largely attribute to including anthropogenic land use. Including fire reduces the difference between simulations and observation-based datasets, which shows that fire is an important process to model the global patterns of vegetation distribution and the carbon cycle. Fire effects on gross primary productivity (GPP), total carbon storage and carbon turnover times are lower. Model-data comparisons, inter-model consistency and information from literature, indicate lower uncertainty in the fire impact on tree cover and vegetation carbon compared to results on GPP, total carbon storage and turnover times. We find the maximum relative impacts of fire in regions of maximum burning, while the maximum absolute impacts are shifted to regions with higher precipitation. We find the strongest impacts of fire in savanna regions (mainly in Africa) where satellite observations show substantial changes in burned area due to land use change over recent decades. Improvements in observing and modelling the spatial patterns of burned area over the recent years additionally increase the confidence in our results compared to previous studies. In light of these results, afforestation programs that aim to increase carbon storage by increasing tree cover in fire-affected regions should be carefully reviewed taking into account the vulnerability of carbon storage to fire and the impact of land use on fire impacts.

New FireMIP simulations

Some test simulations for a new set of historical simulations for FireMIP have been performed. The new set of historical FireMIP simulations will be done with the newly setup model in the next two months.