Project: 901
Project title: Fire in the Earth system
Project lead: Silvia Kloster/Stiig Wilkenskjeld
Report period: 2017-01-01 to 2017-12-31

The work within project bm0901 has in 2017 been largely influence by the PI of the project, Silvia Kloster, unexpectedly leaving the scientific community. Therefore the resources granted to the project have been used by other members of the Fire in the Earth System group than intended when the project was applied for. The work has thus dealt with three fire-related topics:

1) Investigation of the potential for Multiple Stable Vegetation States

Simulations with JSBACH-SPITFIRE with the MPI-ESM were performed to investigate if the coupling to the atmosphere increases the potential for multiple stable states of vegetation. Simulations that were initialized with grass plant functional types (PFT)s only were compared to simulations that were initialized with tree PFTs. In offline simulations without interactive atmosphere and ocean the multistability occurs due to a feedback between fire and vegetation: grasses provide better conditions for frequent fires and have an advantage over trees when disturbances are frequent. On the other end closed tree canopies decrease the fire probability, lead to a lower fire occurrence and under conditions with low disturbance frequency outcompete grasses. The coupling to the atmosphere and ocean has the potential to amplify this feedback by providing hotter, drier conditions for grasses. However, in our coupled simulations the potential for multistability is much lower than in offline simulations where the meteorological conditions do not change with PFT (Figure 1, global tree cover is more similar for the coupled simulations CPL). Variability between years is an important factor with uncertain influence. Offline simulations using 10 or 20 years of climate forcing, however showed very similar results, with respect to global tree cover.

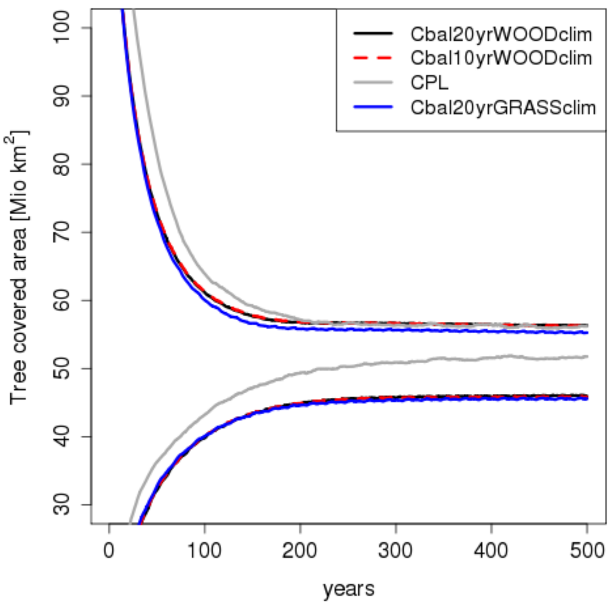

Figure 1: Simulations initialized with either only grass PFTs or only tree PFTs. CPL are coupled simulations. Cbal20yrGRASSclim uses the climate of the last 20 years of the coupled simulation initialized with grasses. Cbal20yrWOODclim are offline simulations forced with the last 20 year climate data of the coupled simulation initialized with tree PFTs. Cbal10yrWOODclim are offline simulations forced with the last 10 year climate data of the coupled simulation initialized with tree PFTs.

JSBACH tends to establish trees in conditions that are too dry to provide enough fuel for fire. Not allowing trees to establish under these conditions lead however to the same result: the coupled simulations show a lower potential for multistability. We also tested whether this happened due to the wind speed parameterization, that decreases fire spread after a certain threshold, but also this did not change the result. The difference between the coupled and offline simulation seems to be a higher productivity of vegetation, leading to a higher resistance of trees in the coupled simulation.

2) Estimating carbon emissions from prescribed wild-fires

Within the CCI-Fire project, carbon emissions from wild-fires and their uncertainties have been estimated. For each JSBACH grid cell monthly burned area (BA) from satellite-based products (CCI-Fire Version 4 and GFED4) - was prescribed. For the period 2005-2011 (period of the CCI-Fire product), global carbon emissions of 1.27 to 2.26 Pg(C)/yr are found with a best guess of 1.91 Pg(C)/yr (Figure 2). The uncertainties tested were those arising from the use of different BA data sets, applying the uncertainty provided with the BA-product as well as the influence of different vegetation covers prescribed (based on the CCI-LC (Land Cover) 2010 product including uncertainties and the standard JSBACH CMIP5 2005 vegetation map) and variations from changing some internal model parameterizations. The main uncertainty turns out to be the uncertainty shipped with the BA-product (full range) closely followed by uncertainties from the land cover (1.55-2.22 Pg(C)/yr). The uncertainty from the tested model parameterizations hardly influenced the global results (1.89-1.99 Pg(C)/yr). These numbers are within the range of published estimates.

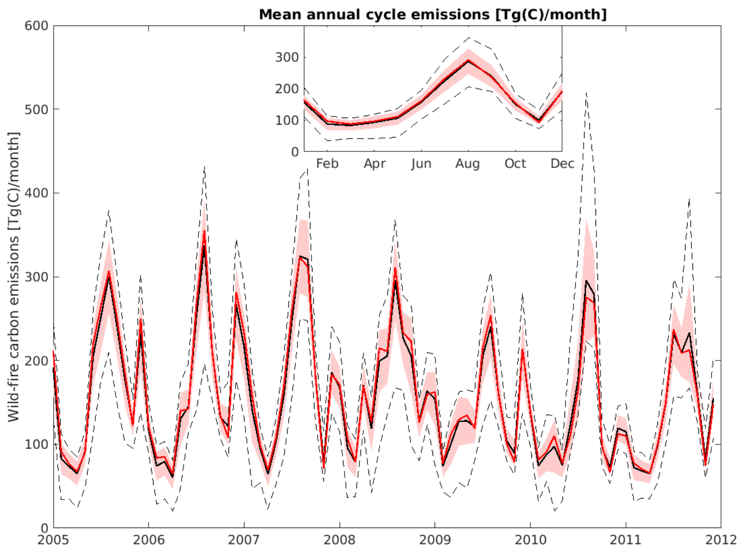

Figure 2: Monthly carbon emissions from wild-fires and their cross-experiment uncertainty. Red line: best guess emissions, black solid line: cross-experiment average emissions, dashed lines: minimum and maximum emissions, reddish shading: Average emissions plus/minus one standard deviation. Insert panel: Same thing but averaged month by month to obtain the mean annual cycle.

3) FireMIP simulations

Additional FireMIP simulations included the coupling between fire and vegetation cover fractions in JSBACH-SPITFIRE. In the previous phase of FireMIP prescribed land cover was used and fire only reduced the carbon pools. The simulations cover from year 1700 until present day, with and without fire, as well as simulations for the Last Glacial Maximum (LGM) with and without fire, with CO2 concentration of 1700 and CO2 concentration of the LGM. This was a first test of JSBACH-SPITFIRE for a paleo- application and shows reasonable results that will be further evaluated within the FireMIP project.

Lasslop, G., Moeller, T., D'Onofrio, D., Hantson, S. and Kloster, S.: *Tropical climate-vegetation-fire relationships: multivariate evaluation of the land surface model JSBACH*, 2018, in review, https://www.biogeosciences-discuss.net/bg-2018-48/

Wilkenskjeld, S., Kloster, S. and Georgievski, G.: *Assessing Carbon Emissions from Wildfires using observed data from ESA-CCI-Fire and the JSBACH vegetation model.* In preparation for Biogeosciences.