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Project acronym: **COMBINE**

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M8.6 Improved DGVMs for Amazon land cover classes operational; impact assessment completed

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The Brazilian Integrated Land Surface Processes Model (Inland)

As part of COMBINE, a new dynamic global vegetation model with improved representation of surface process in Amazonia, Inland, was created. The model derives from IBIS (Integrated Biosphere Simulator, Foley et al. 1996, Kucharik et al. 2000), which had already the ability to simulate land-surface processes such as vegetation dynamics and terrestrial carbon cycle, based on dominant climate and soil properties. From IBIS, our improved model offers the possibility of performing global, regional and local simulations from common input datasets, and was tested using several experiment configurations and evaluations of model outputs (Sampaio et al. 2013), and was first released on November 2012 during a workshop at INPE-CCST in Cachoeira Paulista, Brazil (http://www.ccst.inpe.br/inland). Several activities were performed for the development of INLAND, with emphasis on improvements to better represent surface processes in the study region, including fire and deforestation effects, and coupling to a climate model. With this new model, we performed new analyses to quantify how climate change, deforestation and fire may combine to affect the distribution of major biomes and climate in Amazonia (Cardoso et al. 2013, Sampaio et al. 2013), subject of our major contributions to COMBINE.

Fire model development

The development of the new fire model implemented in Inland was based on methods already tested in global dynamic vegetation models (Cardoso et al. 2013). The model is planned for global applications but having important improvements for ecosystems in South America and Brazil. From the methods initially selected (HadCM3, CTEM (Arora and Boer 2005), SPITFIRE (Tonicke et al. 2010), we adopt the work of Arora and Boer (2005) where fires are simulated as burning occurrence (probability of fire) and effects (burned area and emissions). We concentrated the development and implementation of the fire model for Inland on the simulation of fire probability and effects on vegetation dynamics. For that, we implemented the fire occurrence probability equations of Arora and Boer (2005), where fire potential is driven by the combination of presence of fuel, flammability, and sources of ignitions.

Presence of fuel was represented as in Arora and Boer (2005), which determines that a minimum of 200 gC/m2 of plant biomass is required to sustain a fire. In the Inland implementation, plant biomass was considered the sum of stem and leaf biomass from all vegetation types over land. Flammability was also represented as in Arora and Boer (2005), and it increases exponentially as soil moisture at the root zone approaches the wilting point. In Inland, we calculate flammability based on the moisture at the model's first soil layers, where most of roots are located. Our approach to represent ignitions sources from lightning differed from Arora and Boer (2005) as we assume that lightning activity is simply random.

To account for fire disturbance, we propagated the fire occurrence probability estimation into the calculation of vegetation dynamics. That was done by assuming that the fraction of the vegetation affect by fires is proportional to the fire probability. As other disturbances considered in Inland, fires affect biomass, leaf area index (LAI), and total ecosystem aboveground net primary productivity (NPP). These variables, in turn, will modify the fractional cover of forest and herbaceous canopies.

Implementation of disturb from deforestation

Based on a similar method as fires, deforestation processes were considered in Inland also by accounting for this disturb when calculating the dynamics of the vegetation (Cardoso et al. 2013, Cardoso et al, in preparation). In this case, no assumptions needed to be made because the deforestation can be directly interpreted as a fraction of affected vegetation. However, we assumed that the plant types that will be modified by deforestation include tropical, temperate and conifer broadleaf, evergreen and deciduous trees. The code of Inland was also modified to allow the model to account for deforestation scenarios. For that, the model is able to read maps of deforestation, which can be considered as disturbance for the estimates of vegetation dynamics. Deforestation also affects plant biomass, LAI and NPP, which will, in turn, modify the fractional cover of forest and herbaceous canopies (Sampaio et al. 2013, Sampaio et al., in preparation).

Major results from impact assessment using INLAND

From the application of Inland, we estimate that the impacts of climate change in Amazonia increase when effects of land use changes and fire are considered. The most important changes will potentially occur in the East/Northeast and South of the Amazon, with an increase in surface temperature, and decrease in precipitation and evapotranspiration. Also, it is expected an increase in dry season length and a reduction of upper-canopy biomass related to an increase of the biomass in grasses and a replacement of tropical forest by seasonal forest and/or savanna. The effects of fire and land use cover change and climate changes, resulting in warmer and possibly drier climates, are important to the future of biome distribution in Amazonia. The vulnerability of Amazon rainforest to more frequent and severe droughts, either through a direct effect on tree mortality or through an indirect effect, via increased probability of vegetation fires, is important to understand the potential for an Amazon forest dieback and its implications for the global carbon cycle and future climate (Cardoso et al., in preparation, Sampaio et al., in preparation).

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