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IMPROVING POTENTIAL BIOMES ALLOCATION BY CONSIDERING NATURAL FIRES IN SAVANNAS

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1. INTRODUCTION

Potential biome models are important to represent long-term biosphere-atmosphere interactions in climate studies. Appropriate for coupling to the CPTEC Atmospheric Global Circulation Model (Cavalcanti et al. 2002), the CPTEC Potential Biome Model (CPTEC-PBM) is used for studying large-scale climate-vegetation interactions (e.g. Oyama and Nobre 2004). The model is able to reproduce most of contemporary natural (not considering land use) vegetation features globally, based on dominant climate and soil hydrology characteristics (Oyama and Nobre 2003).

Based on the use of the CPTEC-PBM, potential vegetation in large regions in India and SE Asia is savannas (Oyama and Nobre 2003). Reference maps for current climate conditions, however, indicate that the natural vegetation in those regions is dry forests (Dorman and Sellers 1989) (Fig. 1). This difference is also present in results from other studies (e.g. in Haxeltine and Prentice 1996), and are most probably caused by difficulties in reproducing soil hydrology (Haxeltine and Prentice 1996), local species adaptation (Oyama & Nobre 2003), and long-term occurrence of disturbances such as fire.

Fire is a major natural disturbance, with a strong potential for determining the establishment of savannas in the tropics (Ramos-Neto e Pivelo 2000, Bond et al. 2005). In the long term, biomass consumption and mortality due to fires is higher for trees than for grasses. Thus, fire can generally favor the occurrence of savannas instead of forests (Hoffman et al. 2000, Daly et al. 2000, Bachelet et al. 2000). In order to account for this effect, and improve the formulation and results of the CPTEC-PBM, a simple parameterization of the likelihood of long-term occurrence of natural fires in savannas was built based on broad low-level patterns of wind in the tropics.

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2. METHODS

In order to estimate the potential large temporal and spatial patterns of natural fire in savannas, two main assumptions were made. First, lightning is the primary source of ignition for natural fires (Bowman 2005). For example, field studies in Brazil showed that most of the area affected by fires during 1995-1999 in a Brazilian savanna burned during transitions from dry to wet seasons ignited by lightning strikes (Ramos-Neto e Pivelo 2000).

Secondly, it was assumed that over continental areas in the tropics, large-scale lightning activity is mainly related to the zonal (along parallels of latitude) flux of humidity. Based on prevailing long-term wind direction around the Equator (Fig. 2), the air masses moving from East to West close to the surface generally travel over larger continental areas, where the moisture they bring from the ocean are subjected to convection due to heating from the ground and topography. Links between wind direction, convection and lightning have already been found in other studies for Amazonia (Petersen et al. 2002).

The potential for lightning fires was then parameterized using a simple rule, based on combined information on long-term average and intra-annual variance of the low-level zonal wind (*u*-wind component) (Fig. 3), calculated based on data from the US National Centers for Environmental Prediction (NCEP) Monthly Long-term Mean of U-Wind. Variability of *u* was taken into account to filter out large oscillations in the zonal direction. The rule found was that long-term lightning activity is more likely in tropical regions were combined long-term average and intra-annual variance of the zonal wind is lower than 3.5 m^3/s^3. The regions estimated as savannas by the CPTEC-PBM were then confirmed if they match those areas, or correct to dry forests otherwise.

3. RESULTS

The use of the new simple rule for determining the tropical regions with potential for long-term natural fires due to lightning, allowed the CPTEC-PBM to better estimate savannas. One important result, as shown in Fig. 4, is that regions in India and SE Asia that were initially estimated as savannas are now corrected as dry forests. Other regions of savanna were not changed because they were in accordance with the simple fire rule developed.

4. CONCLUSIONS

The use of the new fire function improved the formulation and the results of the CPTEC-PBM. In addition to account for a relevant process in savannas, the accuracy allocating major biomes in India and Southeast Asia is now higher (total accuracy is now 63,4%) than in previous studies. It is important to note that these results do not account for other reasons that could affect the establishment of savannas (relatively to dry forests), such as soil properties and nutrient cycling (Coutinho 1990, Mistry 1998). Important broad implications of these results include the potential for improved analyses of the relations between climate and vegetation, such as projections of the impacts of different climate conditions on land surface, and the impacts of land-cover changes on climate.

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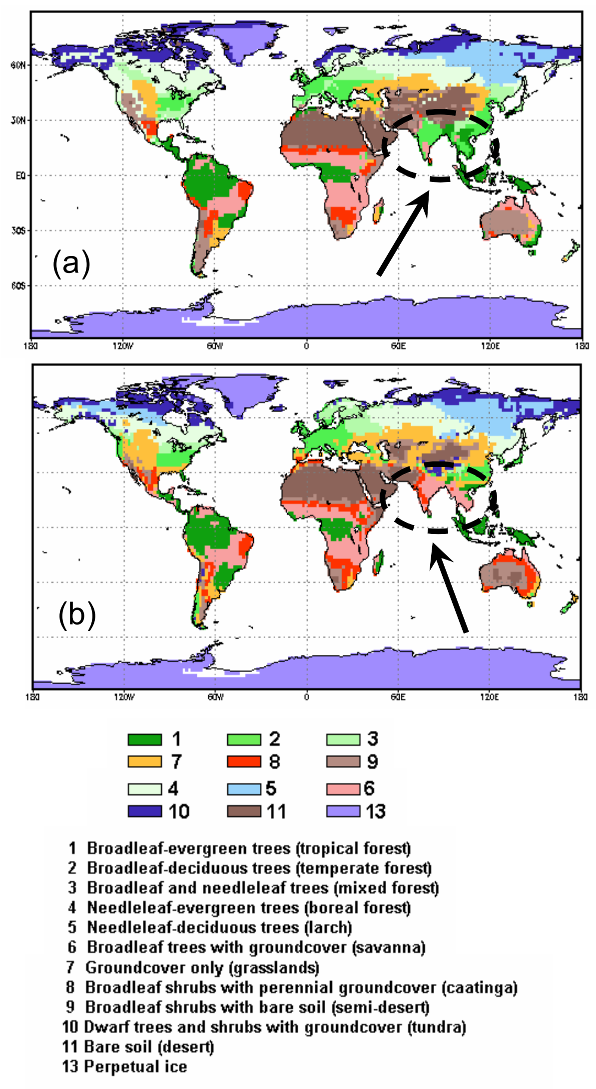

Figure 1 – Reference natural vegetation (a), and potential vegetation estimated with the CPTEC-PBM (b). Dashed lines indicate regions with important differences between the two maps.

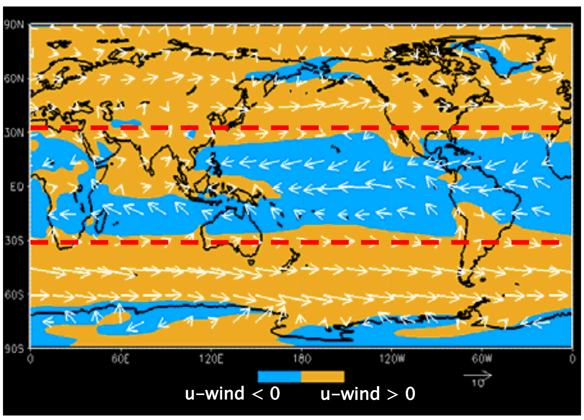

Figure 2 – Long-term average of the zonal component of low-level wind. Blue regions indicate air movement from East to West, and orange indicates air movement from West to East. Dashed red lines approximately enclose the tropics. Data are from NCEP Monthly Long-term Mean of U-Wind.

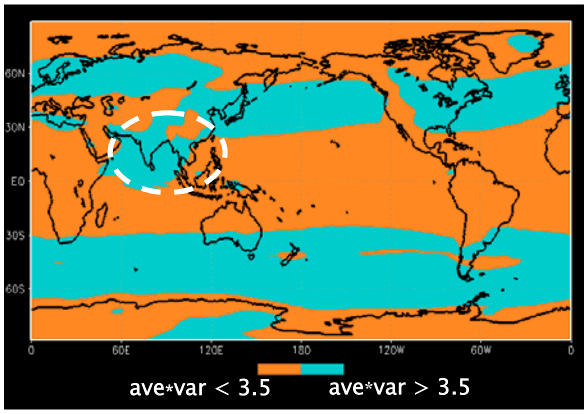

Figure 3 – Combined long-term average and intra-annual variance of the low-level zonal wind. Dashed line show regions where long-term natural fire activity due to lightning is potentially low.

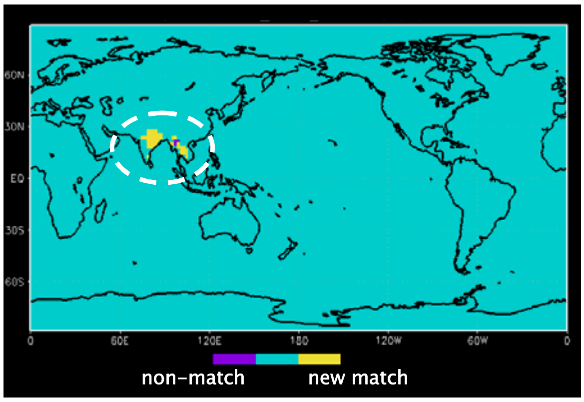

Figure 4 – Impact of the new simple fire function on the results of the CPTEC-PBM. Regions in yellow represent areas that are now correctly represented (better). Regions in blue were not affected by the new rule, and purple indicates new incorrect representation (poorer). Note that the majority of the differences indicated in Figure 1 were corrected.