FIRE RISK IN BRAZIL IN A CHANGING CLIMATE

FLÁVIO JUSTINO[1] ANAILTON S. DE MÉLO[2], ALBERTO SETZER[3]
1 Dr. em Meteorologia, Prof. Adjunto, Depto. de Engenharia Agrícola, Universidade Federal de Viçosa, UFV, Viçosa – MG., (31) 3899 1870. fjustino@ufv.br
2 Mestre em Meteorologia Agrícola UFV/Viçosa-MG.
3 Centro de Previsão de Tempo e Estudos Climáticos , CPTEC/INPE

Apresentado no XVI Congresso Brasileiro de Agrometeorologia – 22 a 25 de setembro de 2009 – Belo Horizonte – MG

RESUMO: Este estudo avalia a susceptibilidade ambiental a ocorrência de fogo na vegetação baseada em um índice potencial de fogo (PFI). Duas simulações do clima baseada conduzidas com o modelo ECHAM5/MPIOM foram usadas para calcular o PFI: atual (1980-2000) e uma simulação para o fim do século XXI (2080-2100). Os resultados indicam que o PFI reproduziu as áreas com maior incidência de queimadas, sendo hábil, portanto para o uso em cenários futuros. Além disso, encontrou-se que sob condições de aquecimento global, o PFI prevê um aumento na área do risco de fogo, particularmente para a região de Amazônica. As mudanças na vegetação previstas para ocorrer no futuro conduzem a incrementos substanciais no valor do PFI, podendo-se concluir que o potencial de fogo da vegetação aumentará devido aos períodos mais longos de seca em comparação às circunstâncias atuais.

PALAVRAS-CHAVE: DPL, ITU, Mudanças Climáticas.

ABSTRACT: This study evaluates the environmental susceptibility to fire occurrence based on a Potential Fire Index (PFI). Two climate simulations from the ECHAM5/MPIOM climate model have been used to calculate the PFI: present day (1980-2000) and an experiment for the end of the 21st century (2080-2100). The results indicate that the proposed PFI methodology could properly reproduce the areas with the highest fire incidence under present conditions. Moreover, it was found that under greenhouse warming conditions the PFI foresees an increase in the re risk area, particularly for the Amazon region. We concluded, furthermore, that changes of vegetation predicted to occur in the future lead to substantial modications in the magnitude of the PFI, and may potentially extend the length of the fire season due to induced longer drought periods as compared to current conditions.

KEYWORDS: THI, Dairy Cattle, Climate Changes.

INTRODUCTION: It has long been documented that a close relation between mankind activities and the environment exists due to the inuence of climate variations on the social well-being. The increase in consumption demands associated to the population growth over the last 10,000 years, has lead to substantial expansion of agricultural activities. Agriculture requires a seasonal management of the soil, which often involves the use of fi re. During the first stage of deforestation, the large and valuable trees are removed. Consequently, the forests become more vulnerable, implying in greater incidence of solar radiation and higher surface temperatures. Among the risks associated with the leveling of large areas of the forests, modi-cation of the hydrological cycle with the reduction of evapotranspiration stands out (Cook and Vizy 2008). Impacts of vegetation fires are prominent in questions which involve future climate changes, especially on the intensification of Global Warming (Bowman et al 2009; Goldind and Betts 2008). Burning of biomass plays an important role in global emissions of carbon and other trace gases (Page et al 2002; Crutzen and Andreae 1990). Vegetation fires on a global scale are the second largest source of greenhouse gas emissions. In Brazil, vegetation fires are responsible for roughly 60-70% of CO2 emissions to the atmosphere. The present study proposes an evaluation of the atmospheric favorability to the occurrence of vegetation fire (hereafter Potential Fire Index (PFI), based upon a new methodology which takes into account the daily values of maximum temperature (tmax), precipitation (prec), vegetation types and the minimum relative humidity (Rhmin). The analyses are performed for present day and greenhouse warming conditions.

METHODOLOGY: In order to compute the PFI for a present day (PD) and greenhouse warming (GW) conditions, two climate simulations conducted by ECHAM5/MPI-OM coupled climate model have been utilized. For the historical part (1950-2000) the concentrations of greenhouse gases (GHG) and tropospheric sulfate aerosols are specified from observations, while for the future part (2001-2100) they follow the SRES A1b scenario. The PFI methodology is based on the temporal and spatial empirical evidence of the occurrence of hundreds of thousands of vegetation fires in Brazil (Brown et al. 2006) during many years. Even though the vast majority of these fires is of anthropogenic origin and spread over most of the country (see Figure 1b), they are related to the annual climate cycle since the purpose of the burnings is a fast and efficient removal of the natural vegetation. The PFI tends to simulate the phenology of di erent vegetation covers, and the PFI increases as the dry season progresses, incorporating the amount and distribution of rains, maximum air temperatures, and minimum relative humidity. To evaluate the PFI under present day and greenhouse warming conditions we have utilized two vegetation cover as proposed by Cook and Vizy (2008). They argue that by the end of the 21st century a 70% of the Amazon forest will be replaced by savanna (Fig. 1). In the case of savannization of the Amazon what effect will this have of the re risk in the Amazon basin? This preliminary study may shed some light on this relevant question. Sequence of the PFI calculation: 1º) Determine daily for a given geographic area, the value of precipitation, in millimeters (mm) accumulated for the eleven immediately preceding periods of 1, 2, 3, 4, 5, 6-10, 11-15, 16-30, 31-60, 61-90 and 91-120 days. 2º) Calculate the "Precipitation Factors" (PF) with values ranging from 0 to 1 for each of the eleven periods, using an empirical exponential function of the precipitation in millimeters for each period. The respective equations used are: (1) PF1 = exp(-0,14Prec); (2) PF2 = exp(-0,07Prec); (3) PF3 = exp(-0,04Prec); (4) PF4 = exp(-0,03Prec); (5) PF5 = exp(-0,02Prec); (6) PF610 = exp(-0,01Prec); (7) PF11-15 = exp(-0.008Prec); (8) PF16-30 = exp(-0.004Prec); (9) PF31-60 = exp(-0.002Prec); (10) PF61-90 = exp(-0.001Prec); (11) PF91-120 = exp(-0.0007Prec). 3º) Calculate the "Days of Drought" (DD) according to the equation: DD = 105 (PF1 X...XPF91-20). Determine the basic potential fire (BR) for each of the five types of vegetation considered, using the equation: BR = 0,9 (1 + sin($A_{n1;5}$ DD))/2. The $A_{n1;5}$ stands for the types of vegetation. Firstly, the BR is corrected based on the minimum relative humidity of the air. The risk (RH) increases when humidity is less than 40% and diminished for values greater than 40%. Humidity data from observations during the 18h GMT are used, in search of the minimum value. The linear adjustment equation is: $RH = BR(-0{,}006 * RH_{min} + 1{,}3)$. Secondly, the fire risk is corrected based on the maximum temperature of the air. The risk (PFI) increases for temperatures higher than 30°C and decreases for temperatures lower than 30°C. Temperature data from observations during the 18h GMT are used, in search of the maximum value. The linear adjustment equation is: $PFI = RH\ (0{,}02Tmax + 0{,}4)$. After performing the necessary calculations, the PFI attains values between 0 and 1, in the following categories: minimum,low, medium, high and critical.

RESULTS: The analyses discussed here are for the month with the highest fire activity in Brazil which is September. Climate conditions in September are more favorable to the occurrence of vegetation fires as compared to August (Fig. 2). High temperature, low relative humidity and the long absence of rain lead to an intensication of the PFI, except over the western Amazon basin (Fig. 2g). As found for August, the central part of Brazil is the critical region, in particular the States of Mato Grosso, Para and Maranhão. This result matches very closely the highest fire activity in Brazil as detected by satellite. Turning to the investigation of the environmental susceptibility to fire under GW conditions, is evident the influence of induced low relative humidity, high temperatures and the high DD in leading the positive PFI anomalies. For this month, the PFI associated with the inclusion of greenhouse forcing attains values up to 0.9 which characterize that the fire risk is in the critical level (Fig. 2h). By combining the climate and vegetation as projected to Brazil by 2080-2100 (Fig. 2i), one may note remarkable changes in the PFI as compared to present conditions. The replacement of the rainforest by savannas in the States of Para, Acre and Rondônia cause an increase in the PFI. However, in the States of Minas Gerais and Mato Grosso, the index associated with the days of drought decrease and changes in vegetation from present day savanna to mixed shrubland/grassland lead to lower atmospheric favorability to fire (Fig. 2i).

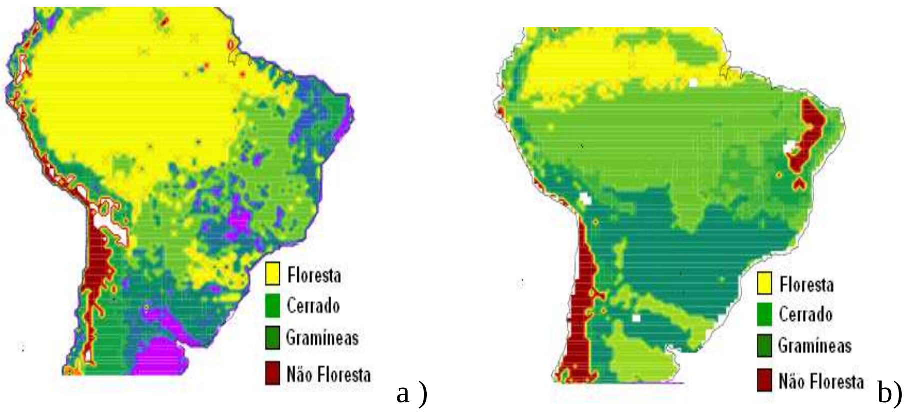

Figure 1. Vegetation distribuição for present day (a) and future (b).

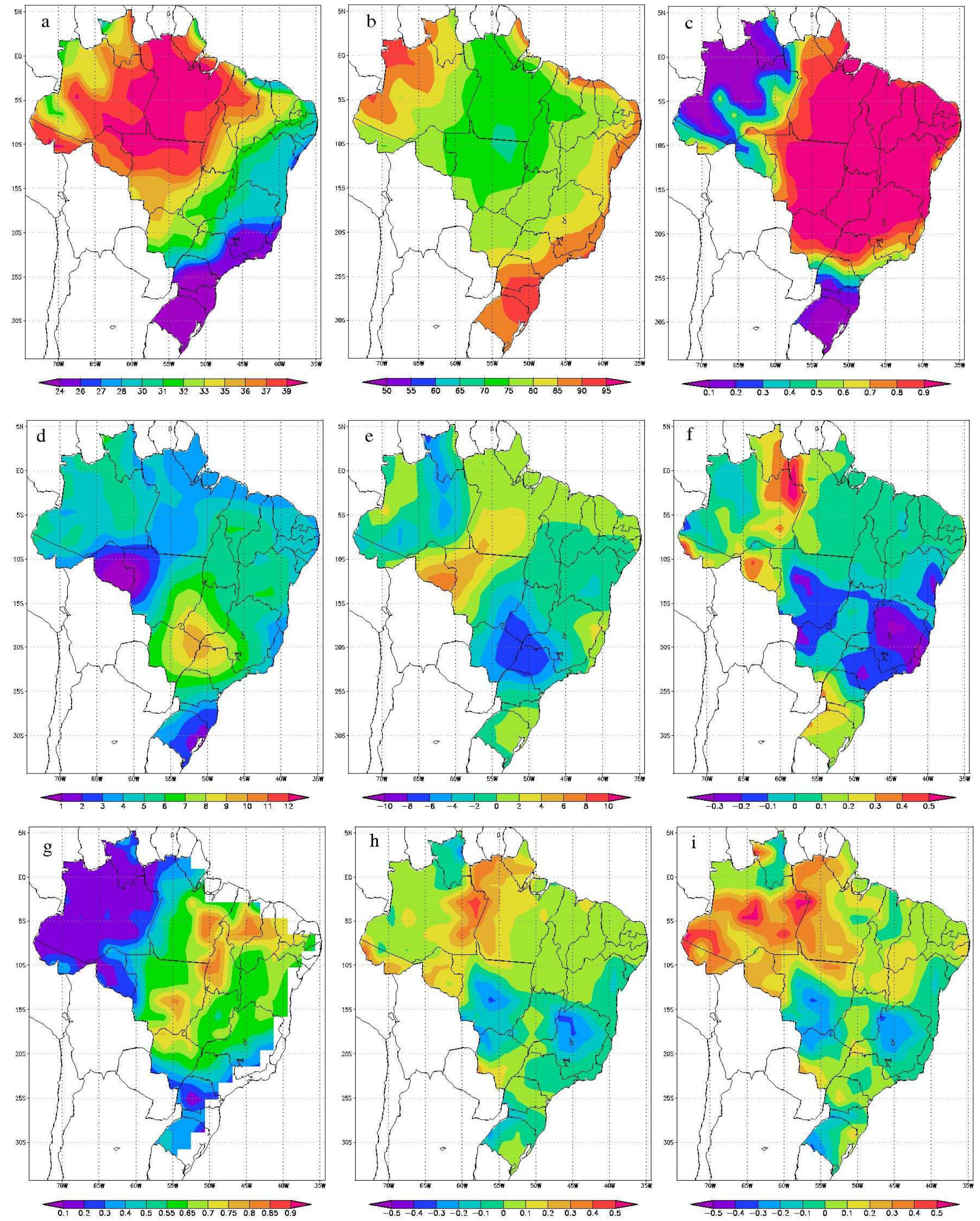

Figure 2. Monthly mean conditions in June. a) maximum temperature, b) minimum relative humidity c) days of drought, d) maximum temperature anomalies, e) minimum relative humidity anomalies f) days of drought anomalies between GW and PD simulations. g) potential fire index

(PFI) for present day conditions, h) PFI anomalies between GW and PD simulation with present day vegetation, i) PFI anomalies between GW and PD simulation but with future vegetation.

CONCLUTION: Calculation of the PFI using the two different vegetation scenarios, according to current conditions and those proposed for global warming scenario, shows that the future PFI is extremely sensitive to the conditions imposed by the vegetation. When forests were substituted for savanna, a greater fire risk was obtained. Moreover, areas of savanna which were substituted for pastures showed lower PFI values. Thus, according to the anomalous atmospheric conditions predicted for the future, Brazil will be more favorable to large scale vegetation fires, principally in the Amazon region and in the northeastern portion of country. It is known that the majority of Brazilian vegetation fires have an anthropogenic origin. Therefore, the presented results are entirely independent of the human action and provide only the atmospheric favorability to the occurrence of re. Moreover, res of anthropological origin are often directly related to agro-forestry activities. Current socioeconomic and cultural factors may be completely different in the future, potentially reducing the number of fires even when atmospheric conditions appear to be susceptible to vegetation fires. One should note, however, that an increase in lightning incidence, an approximate 56% change in global lightning frequencies for every 1C global warming as proposed by Price and Rind (1994), may cause a greater number of natural vegetation fires in the future.

REFERENCES:

BOWMAN, D. M. J. S. ET AL. Fire in the Earth System. Science, v. 324, p. 481-484, doi:10.1126/science.1163886, 2009.

BROWN, I. F., SCHROEDER, W., SETZER, A. W., DE LOS RIOS MALDONADO, M., PANTOJA, N., DUARTE, A., MARENGO, J. Monitoring Fires in Southwestern Amazonia Rain Forests. EOS Transactions. American Geophysical Union, v. 87, p. 253-264, 2006.

COOK, K., VIZY, E. K. Effects of Twenty-First-Century climate change on the Amazon rain forest. Journal of Climate, v. 21, n 3, p. 542-560, 2008.

CRUTZEN, P. J., ANDREAE, M. O. Biomass burning in the tropics: impact on atmospheric chemistry and biogeochemical cycles. Science, v. 250, p. 1669-1678, 1990.

GOLDING, N., BETTS, R. Fire risk in Amazonia due to climate change in the HadCM3 climate model: Potential interactions with deforestation. Global Biogeochem. Cycles, v. 22, GB4007, doi:10.1029/2007GB003166, 2008.

PAGE, S. E., SIEGERT, F., RIELEY, J. O., BOEHM, H. D. V., JAYA, A., LIMIN, S. The amount of carbon released from peat and forest fires in Indonesia during 1997. Nature, v. 420, p. 61-65, 1997.

PRICE C, RIND D. Possible implications of global climate change on global lightning distributions and frequencies. J. Geophys. Res., v. 99(D5), 10, p. 823831, 1994.