Impacts of Climate Change Scenarios for 2091-2100 on the Biomes of South America

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INTRODUCTION

Field observations (Gash and Nobre, 1997) and numerical studies (e.g., Nobre et al., 1991) reveal that large scale deforestation in Amazonia could alter the regional climate significantly. Evapotranspiration is reduced and surface temperature is increased for pastures. That effect might lead to a 'savannization' of portions of the tropical forest domain. Recently, Oyama and Nobre (2003) showed the existence of a second stable biome-climate equilibrium with savannas covering eastern Amazonia and semi-deserts in Northeast Brazil. However, there have been fewer studies on the impact of global climate change on South America, particularly on its biomes such as Cox et al. (2000). This preliminary investigation addresses this question by looking how natural biomes could change in response to various scenarios of climate change.

CLIMATE CHANGE SCENARIOS FOR SOUTH AMÉRICA FOR 2091-2100

Figures 1 and 2 show average temperature and rainfall anomalies for the decade 2091-2100 derived from five different Global Climate Models (GCM) available at the IPCC Data Distribution Center (IPCC DDC, 2003): models from the Geophysical Fluid Dynamics Laboratory (GFDL), USA; Hadley Centre for Climate Prediction (HADCM3), UK; CSIRO (CSIRO-Mk2), Australia; Canadian Climate Center (CGCM2), Canada; and, CCSR/NIES, Japan. Two different GHG emissions scenarios (IPCC, 2000) were used: the A2 emissions scenario of high GHG emissions and B2, of low GHG emissions. Typical model horizontal resolution is about 300 km. Analyses of these figures reveal larger differences in temperature and rainfall changes among models than among emission scenarios for the same model. As expected, the main source of uncertainty for regional climate change scenarios is that one associated to rather different projections from different GCMs. The projected temperature warming for South America range from 1 to 4 C for emissions scenario B2 and 2 to 6 C for A2. The analysis is much more complicated for rainfall changes. Different climate models shows rather distinct patterns, even with almost opposite projections. For instance, GFDL GCM indicates increase in rainfall for tropical South America, whereas other GCMs show reduction (e.g., HADCM3) or little alteration. In sum, current GCMs do not produce projections of changes in the hydrological cycle at regional scales with confidence. That is a great limiting factor to the practical use of such projections for active adaptation or mitigation policies.

TEMPERATURE ANOMALIES (DEG C) FOR 2091-2100

A2 High GHG Emissions Scenario | **B2 Low GHG Emissions Scenario**

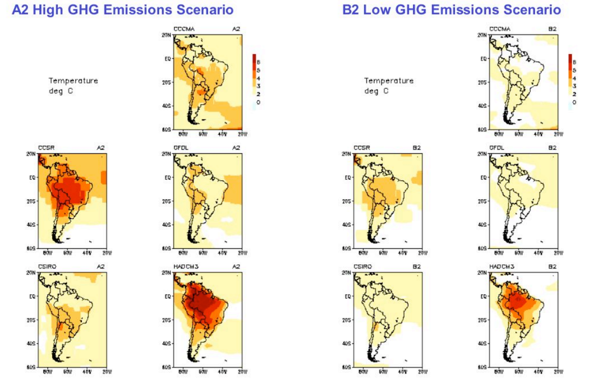

Figure 1. Climate change projections for 2091-2100 of surface temperature anomalies (C) for 5 Global Climate Models (with respect to each model's average temperature for the base period 1961-1990).

PRECIPITATION ANOMALIES (MM/DAY) FOR 2091-2100

A2 High GHG Emissions Scenario | **B2 Low GHG Emissions Scenario**

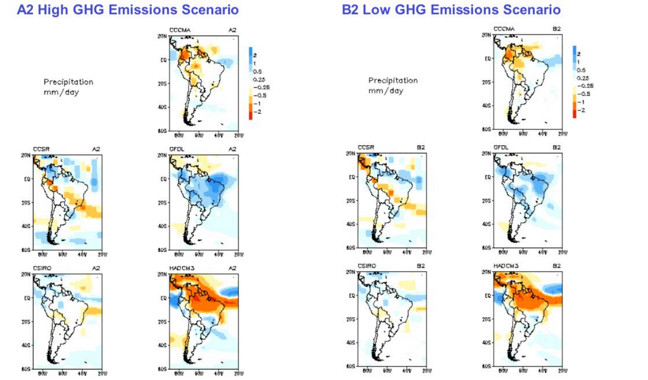

Figura 2. Climate change projections for 2091-2100 of rainfall anomalies (mm/day) for 5 Global Climate Models (with respect to each model's average rainfall for the base period 1961-1990).

PROJECTIONS OF BIOME CHANGE AND REDISTRIBUTION FOR 2091-2100

Next, we deal with the question of the possible alterations of South American biomes in response to the projected climate changes of Figures 1 and 2 for the decade 2091-2100. We use CPTEC Potential Vegetation Model (PVM) (Oyama and Nobre, 2004). PVM is a model that describes reasonably well the large-scale distribution of world's biomes as a function of five climate variables. Figure 3 shows the projected biome redistributions in South America. As could have been foreseen, the major differences in biome distributions are found among different models rather than from the two emissions scenarios for a given model.. In 4 out of the 5 GCMs a tendency for reduction in the tropical forest area can be seen and, in general, replacement for drier climate biomes (savannas replacing forests, dry shrubland replacing savannas, semi-desert vegetation replacing dry shrubland) in tropical South America. Impact on extratropical South America is somewhat smaller. The combination of warming and rainfall changes indicates less water availability for large portions of tropical South America in 4 out 5 GCMs. Impacts on agriculture and water resources can be expected for those regions.

PROJECTED BIOME DISTRIBUTIONS FOR SOUTH AMERICA FOR 2091-2100

A2 High GHG Emissions Scenario | **B2 Low GHG Emissions Scenario**

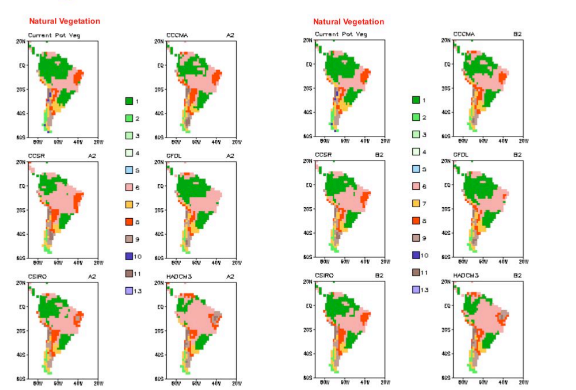

Figura 3. Projected distribution of natural biomes in South America for 2091-2100 based on the climate scenarios of Figures 1 and 2 from 5 Global Climate Models. The calculations of the biomes in equilibrium with the new climate were carried out with the use of CPTEC Potential Vegetation Model (PVM). PVM associates the main world's biomes to 5 climate variables, derived from monthly distribution of surface air temperature and precipitation. The main biomes for South America are represented by the following color code: green = tropical forest; pink = savanna; red = dry shrubland; yellow = extratropical grasslands; light brown = semi-desert; dark brown = desert; light green = deciduous Forest. The upper left-hand panel for each emissions scenario represents the natural biomes in equilibrium with the current climate. Notice that they represent the potential biomes, but not the actual vegetation distribution, which is a result of historical land use and land cover change. The left-hand panel is for the A2 emissions scenario, whereas the right-hand panel is for the B2 emissions scenario.

CONCLUSIONS

The future of biome distribution in tropical South America in face of the synergistic combination of impacts due to both land cover and climate changes points out to 'savannization' of portions of the tropical forests of Amazonia and 'desertification' of parts of Northeast Brazil. For Amazonia, that trend would be greatly exacerbated by fires (Nepstad et al. 1999). Considering that the time scale for ecosystem migration of centuries to millennia is much larger than the expected time scale of decades for GHG-induced climate change, global change has the potential of profoundly impacting ecological diversity of plant and animal species on a mega-diverse region of the planet. In sum, one cannot really expect effective adaptation policies when it comes to the potential of massive ecosystem disruptions that could be brought about by the project climate changes of this century. That would reinforce the case of mitigating climate change to avoid a dangerous interference with the ability of natural ecosystems to adapt to it.

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