IMPACT OF AMAZON DEFORESTATION ON TEMPERATURE AND PRECIPITATION IN SOUTHERN MEXICO, CENTRAL AMERICA, AND THE CARIBBEAN THROUGH REGIONAL CLIMATE SIMULATIONS

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INTRODUCTION

The Amazon, the largest tropical forest in the world, covers 9 countries and measures 7 x 10^6 km^2 (Aquae Foundation, 2016). It contains 80,000 species of plants, crucial for regulating the climate and the water cycle. Studies have indicated a decrease in precipitation, evaporation and an increase in temperature in the region (Avissart and Werth, 2005). Deforestation, drought and climate change threaten its ability to absorb CO_2 and balance emissions. Intense deforestation has been recorded in the last 40 years, with climatic and human health consequences (Alves et al., 2017). The conversion of the Amazon into grasslands would impact heat stress and have effects on other regions (Alves et al., 2021). Deforestation simulation studies need to be conducted to understand these effects.

MATERIALS AND METHODS

The ICTP RegCM4 model was used to perform 21-year simulations (1996-2016) in the CORDEX-CAM domain (Figure 1). These simulations included a control run (CTL), which maintained the prescribed vegetation according to the CLM4.5 land surface model (Oleson et al., 2013), and a tree-to-grassland numerical deforestation run (AMZ). Figure 1 shows the specific area of the Amazon region where deforestation was applied (area enclosed in a black box). To evaluate the model performance, data from precipitation and temperature observations provided by the CPC (NOAA/OAR/ESRL PSL) with a resolution of 0.50°, as well as data from the ECMWF ERA 5 reanalysis with a horizontal resolution of 31 km were used (Hersbach et al., 2020; Copernicus Climate Change Service [C3S], 2017).

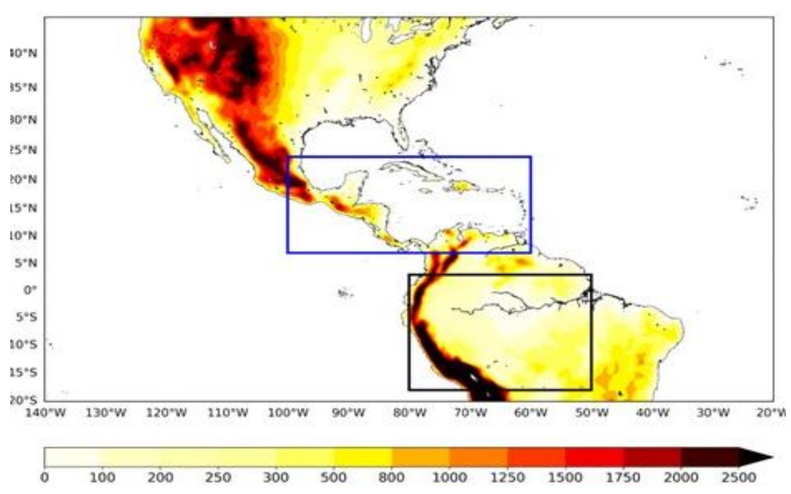

Figure 1. CORDEX-CAM domain, topography (m), region to be deforested (enclosed in black box) and region of southern Mexico, Central America and the Caribbean (enclosed in blue box).

RESULTS AND DISCUSSION

The performance of the RegCM4 model was evaluated in comparison with CPC and ERA5 data (Figure 2). A cold bias in RegCM4 temperature was observed across the region, compared to the CPC (Figure 2a). However, compared to ERA5 (Figure 2b), a warm bias was found in most of the region, except in the Yucatan Peninsula and Cuba, where the bias is consistent with CPC. This behavior in temperature bias is consistent with previous RegCM studies in the CAM domain (Corrales-Suastegui et al., 2021). Regarding precipitation, RegCM4 was shown to be humid in much of the region, with the exception of some areas of southern Mexico where the model was drier (Figure 2b,d). Despite the biases in both variables, the model presents similar characteristics to the observations and the reanalysis.

The AMZ deforestation (change from trees to grasslands) experiment showed a warming effect in southern Mexico, the Yucatan Peninsula, and Central America, with a temperature increase up to ~0.2°C (Figure 3a). However, we found a negative change of ~0.1°C along the Caribbean coasts and Cuba. Regarding precipitation (Figure 3b), a reduction was found along the Pacific Coast and in large regions of southern Mexico, Central America, and Cuba, with a decrease of ~0.25 up to ~1 mm/day. These results are consistent with a recent global study that suggests that tropical deforestation, including the Amazon, could have a negative impact on precipitation in regions such as southern Mexico, Central America, and the Caribbean (Smith et al., 2023).

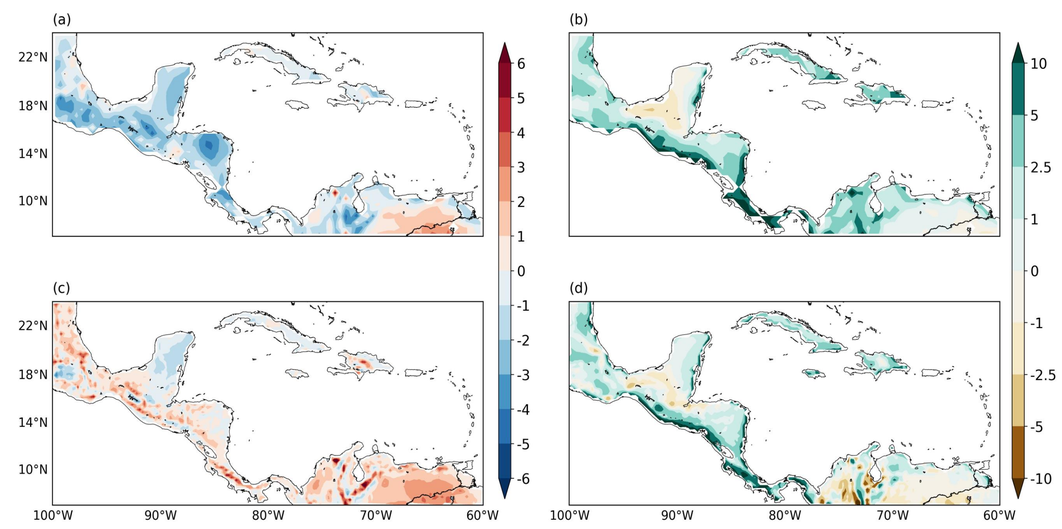

Figure 2. Difference in the 20-year average (1997-2016) for (a) surface temperature (°C) and (b) precipitation (mm/d) for CTL minus CPC. (c) and (d) similar to (a) and (b) but for CTL minus ERA5 during the same period.

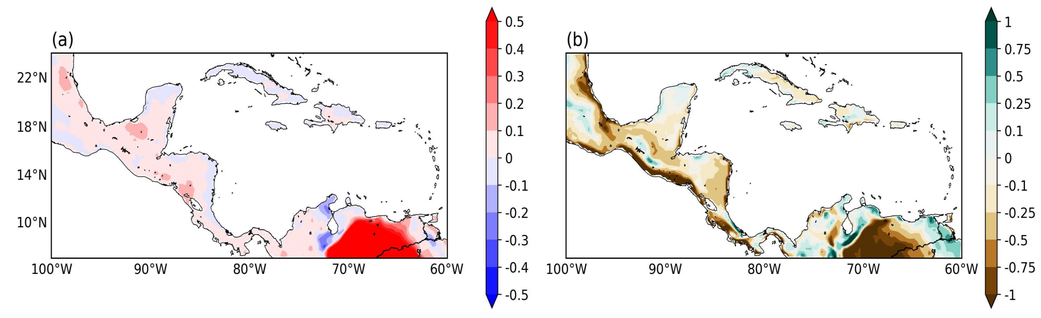

Figure 3. Difference (AMZ minus CTL) in (a) surface temperature (°C) and (b) precipitation (mm/d) during the period 1997-2016.

CONCLUSIONS

In this study, the RegCM4 model was used to analyze the impact of deforestation in the Amazon on precipitation and temperature in southern Mexico, Central America, and the Caribbean using 21-year simulations. The deforestation simulation results indicate a significant decrease in regional precipitation consistent with recent global research on tropical deforestation. Regarding temperature, the AMZ simulation showed a warming response over southern Mexico and Central America in contrast to the Caribbean region, where the model showed a cooling effect. Additional research with high resolution simulations is required to understand better the effect of a complete deforestation in the Amazon on far regions.

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Acknowledgments: The authors gratefully acknowledge the computing time granted by LANCAD and CONACYT on the supercomputer Yoltla/Miztli/Xiuhcoatl at LSVP UAM-Iztapalapa/DGTIC UNAM/CGSTIC CINVESTAV. ACS's research is supported by INIFAP (Mexico).