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Simulating a response from a rain forest ecosystem in eastern Amazonia to the RCP4.5 and RCP8.5 scenarios

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1. Introduction

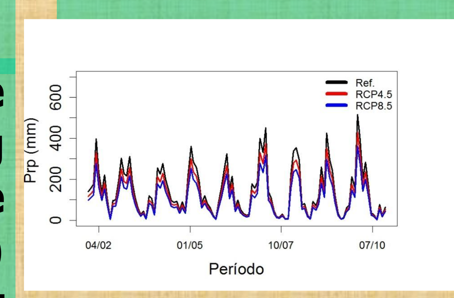
Several climate models predict more intense and frequent droughts in the Amazon region due to the increase of gases that cause the greenhouse effect. As a result, carbon stocks in Amazonian forests can be substantially reduced, as severe droughts tend to increase mortality and decrease tree growth. The proposal of this work comprises the simulation with the results of climatic variation found by the model Eta-HadGEM2-ES modifying the parameters of temperature, long-wave radiation (ROL), precipitation, specific humidity and atmospheric CO2 in the model ED2.2 according to what was found for the RCP4.5 and RCP8.5 scenarios.

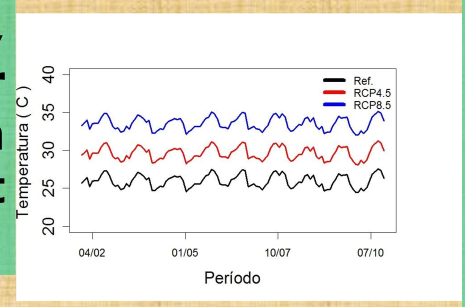
2. ED2: Ecosystem Demography Model

The Ecosystem Demography (ED) model is a terrestrial biosphere model that tracks the dynamics of ecosystem structure and functioning on a local scale representing the tree population, size and age differentiating individuals into functional types of ecosystems. (PFTs) simulating the dynamics in individual scale and competition (Moorcroft et al., 2001). The model has the representation of three different successional stages in the forest: initial, intermediate and advanced, are the three functional types of plants (PFTs). Different from other models of vegetation dynamics, in ED2 the PFTs are defined based on their physiological and morphological characteristics that represent the different ways in which plants use their resources.

3. Variables modified in the ED model for the RCP4.5 and RCP8.5 scenarios

	Temperature	LWR	PRP	q	CO_2
Cenário RCP4.5_2	+3.6 °C	+22.40 W.m^{-2}	-17%	+13%	650ppm
Cenário RCP4.5_3	+3.6 °C	+22.40 W.m^{-2}			
Cenário RCP4.5_4			-17%		
Cenário RCP4.5_5					650ppm
Cenário RCP8.5_2	+7.5°C	+41.40 W.m^{-2}	-30%	+7%	1100ppm
Cenário RCP8.5_3	+7.5°C	+41.40 W.m^{-2}			
Cenário RCP8.5_4			-30%		
Cenário RCP8.5_5					1100ppm

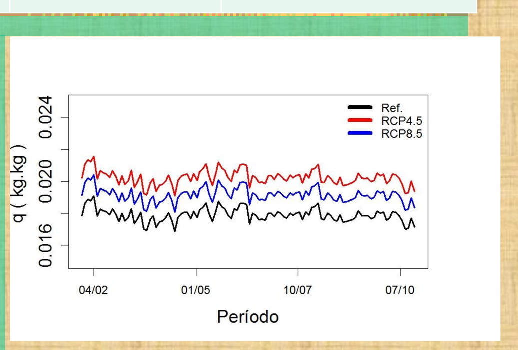


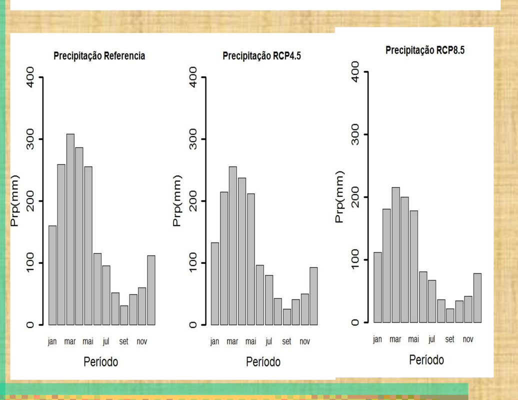


Comparison between temperature, precipitation and specific humidity data for the control, RCP4.5 and RCP8.5 scenarios.

Black, red and blue lines represent the control scenarios, RCP4.5 and RCP8.5 respectively.

For this scenario, the work of Lyra et al., (2016) was used as reference.





4. Results and discussion

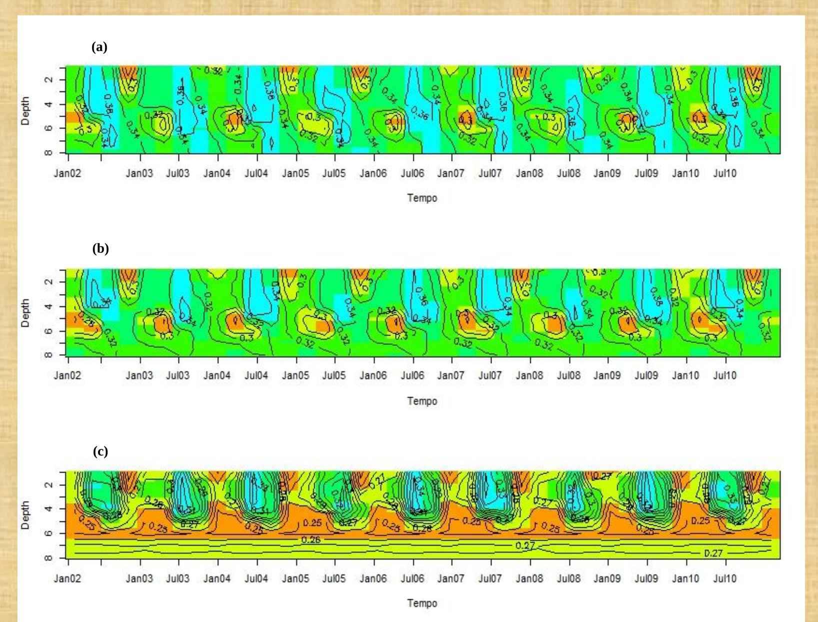


Fig.2. Mean for the last nine simulated years of the soil moisture profile for the control (a), RCP4.5 (b) and RCP8.5 (c) scenarios. The seasonal pattern of soil moisture in response to precipitation is remarkable. It is observed that the soil in the control condition (a) can recharge moisture to deeper layers. The simulations with rain reduction to 17% for the soil of Fig. 2b led to the reduction of soil moisture profile for the deeper layers, with higher values of humidity around ≈ 5m. For the scenario with rain reduction of 30% the deeper layers had a reduction of humidity with values around 0.27 m3.m-3. The pattern of moisture reduction in the layers around 5 m indicates the depth where there is greater absorption of water by the roots of plants.

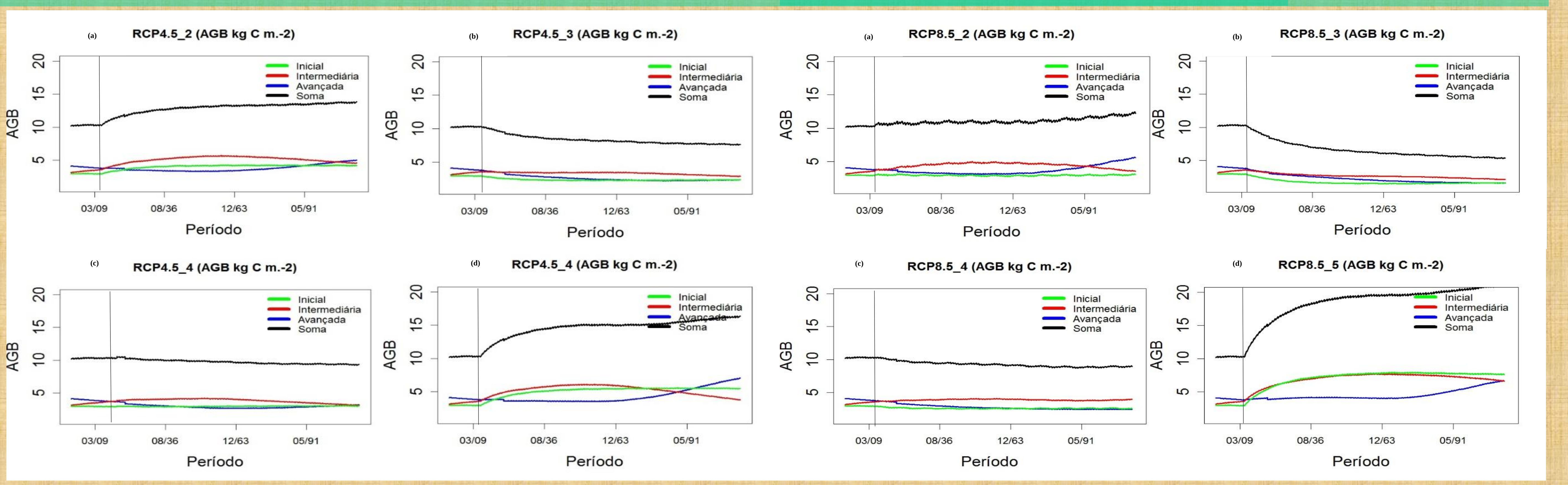
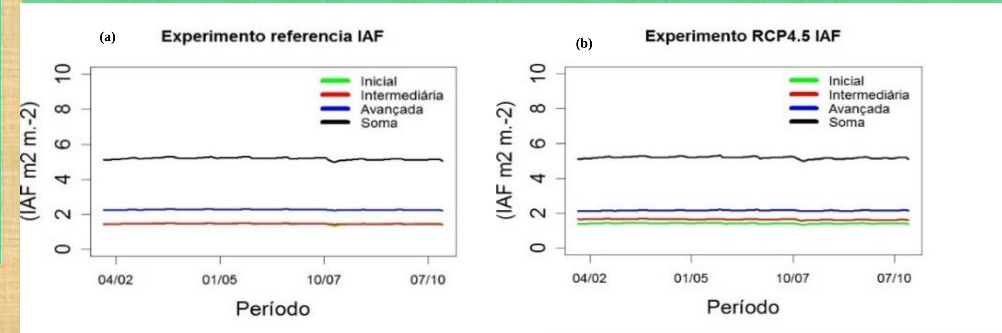


Fig.3. Time series of aerial biomass for the four simulations with scenarios RCP4.5 and RCP8.5. (A) experiment with a modification of the meteorological parameters according to RCP4.5 and RCP8.5, (b) experiment with increase of temperature, (c) experiment with decrease of precipitation, (d) experiment with CO2 increase. The vertical black line indicates the point from which the climate changes were simulated. Although the RCP4.5 and RCP8.5 scenarios presented by Lyra et al., (2016) show projections of climatic changes accentuated with temperature increase and rainfall reduction, model ED2 simulated an increase in AGB of 25% and 8% on average For the two scenarios respectively. Lyra et al. (2016) found in their results a decrease of 9% and 50% of the area of tropical forest in the eastern region of the Amazon. Although the increase in T and reduction of PRP in the simulations showed that for these meteorological parameters there could be a reduction of the carbon stock in the forest, the increase of the CO2 concentration for the ED model favored the growth of the trees during the simulated 100 years. For future simulations it would be important to improve the CO2 absorption function by the model so that it is well balanced with the climatic conditions, representing more accurately the dynamics of the forest in a climate change scenario. Soil moisture uptake was more favorable to plants with greater root depth, favoring them in drier conditions.



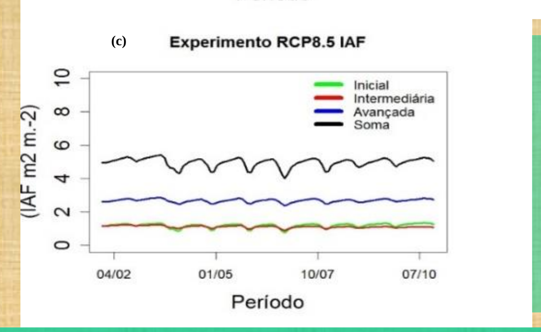


Fig. Temporal leaf area index (LAI) for the experiments: (a) reference, (b) RCP4.5 and (c) RCP8.5. The model simulated well the LAI variation as a function of the availability of water in the soil, showing that in dry periods, LAI reduces and increases according to the availability of water in the soil. The model was sensitive to the decrease of the prepitation and increase of the temperature leading to reduction of the total aerial biomass, but for the increase of the CO2 concentration the model ED2.2 was not configured to saturate in high levels of CO2. However, it is still not possible to say what the decrease or increase of the carbon absorption by the plants will be under conditions of CO2 increase in the atmosphere. Field studies are needed to calibrate the models with this scenario.

5. Conclusions

• The simulations for the RCPs scenarios showed that despite the negative effect of the increase in temperature and the decrease of prp on the Amazon in the model ED2, CO2 fertilization has a positive impact on the vegetation contributing to the increase of AGB. This result indicates that, even if the ED model does not saturate due to the increase of the CO2 concentration, when a scenario with temperature increase, precipitation decrease and CO2 increase in the atmosphere simultaneously and with different magnitudes, there were significant differences in Vegetation growth for RCP4.5 and RCP8.5, indicating that in a drier, warmer climate the rainforest can reduce the carbon increment in its biomass by up to 17% to the (more pessimistic) RCP8.5 scenario by slowing down its growth and not contributing as a CO2 sink to the environment.

6. References

1. Moorcroft PR, Hurtt GC, Pacala SW, 2001. A method for scaling vegetation dynamics: The Ecosystem Demography model (ED). Ecological Monographs 71: 557-587.
2. Lyra et al., 2016. Sensitivity of the Amazon biome to high resolution climate change projectionst.