The role of land use change over Amazon Forest in simulating climatology and extreme hydroclimatic indices

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Introduction

The most important anthropogenic influences on climate are the emission of greenhouse gases and land use change (LUC).
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In particular the Amazon (AMZ) basin is a highly vulnerable area to climate change due to substantial modifications of the hydroclimatology of the region expected as a result of LUC forcing.

However, the magnitude and pattern of these changes are still uncertain.
Objectives

• The goal of this work was to analyze the simulated Amazon Basin deforestation and its impacts on the regional climate, under current day conditions, using idealized experiment over South America (SA) CORDEX domain

• and analyze the changes of different hydroclimatic extreme indices under LUC conditions over the AMZ and its impacts over South America
Experiments set-up

- **Regional Climate Model** RegCM4 (Giorgi et al., 2012) coupled to the version 4.5 of the **Community Land Model** (CLM4.5 - Oleson et al., 2013) over CORDEX SA domain

![Figure 1 – South America CORDEX domain and topography (m)](image-url)
Experiments set-up

- **Regional Climate Model** RegCM4 (Giorgi et al., 2012) coupled to the version 4.5 of the **Community Land Model** (CLM4.5 - Oleson et al., 2013) over CORDEX SA domain

- Default land cover map (Cтрлexp) and Deforestation scenario (LUCexp), i.e., we shifted all broadleaf evergreen tropical trees (tropical rain forest) to $C_3$ grass.
**Experiments set-up**

- Default land cover map (Ctrlexp) and Deforestation scenario (LUCexp), i.e., we shifted all broadleaf evergreen trees tropical (tropical rain forest) to C$_3$ grass.

- Green colour represents the broadleaf evergreen tropical trees that was replaced for C$_3$ grass in LUCexp

- The horizontal black bars indicate the cross section (5°S-5°N) selected for more detailed analysis
Experiments set-up

- **Regional Climate Model** RegCM4 (Giorgi et al., 2012) coupled to the version 4.5 of the **Community Land Model** (CLM4.5 - Oleson et al., 2013) over CORDEX SA domain

- Default land cover map (Ctrlexp) and Deforestation scenario (LUCexp)

- Both simulations were driven by Era Interim reanalysis (Dee et al., 2011) from 1979 to 2009

- Ctrlexp is validated by comparison with the observational data from CRU

- The climate change signal due to deforestation is evaluated by comparing the climatology of the LUCexp with that of the Ctrlexp.

- We analyze 3 indices of temperature and precipitation extremes, defined as: Heat Wave Day Index (**HWD**), Maximum Consecutive Dry Day index (**CDD**) and Heavy Precipitation Index (**R95**)
Model Evaluation – CtrlExp

- CtrlExp captures (with some bias) the SA climatology (prec and temp)
The changes in annual mean temperature in the deforestation experiment compared to Ctrl indicate a warmer anomaly over the deforested areas.

And it contributes to decrease the surface pressure and, as a consequence, a thermal low is formed.

This signal was also found by other deforestation studies over SA (Lejeune et al., 2014, Silva et al., 2015).
Why this increase in air temperature?

- Increase of Sensible Heat Flux (green line)
- Decrease of Latent Heat Flux (Blue line)
Regional Effects of deforestation

LUC-Ctrl Precip (mm/day)

- Dipolar response consisting of reduced precipitation over western AMZ and an increased precipitation over eastern AMZ

- This signal was also found by other deforestation studies over SA (Lejeune et al., 2014)
Why this dipole pattern in precipitation?

Precipitation LUC-Ctrl (mm/day)

DIV – 10^{-5} \text{s}^{-1} (LUC-Ctrl)
Why this dipole pattern in precipitation?

Precipitation LUC-Ctrl (mm/day)

DIV (LUC-Ctrl)

Convergence
Why this dipole pattern in precipitation?

The changes in land use causes a reduction in the surface roughness, an increase of the thermal gradient between tropical Atlantic Ocean and the land, with a consequent intensification of the flow at low levels (850 hPa), mainly on the eastern region.
Why this dipole pattern in precipitation?

At high levels (250 hPa) develops a weak anticyclonic circulation in LUCexp due to the increase of the precipitation over this area.
Hydroclimatic Indices

The changes in land use increase the Heat wave day index (HWD)

Remotely effect of HWD over other regions in SA continent.
The changes in land use increase the Maximum Consecutive Dry Day Index (CDD), but not over the deforestation area.
Hydroclimatic Indices

The changes in land use increase the Heavy Precipitation Index (R95) with a strong signal over the AMZ region.
Conclusions

• A dipolar response consisting of reduced precipitation over western AMZ and an increased precipitation over eastern AMZ due to the changes in the circulation.

• Concerning the temperature we found a predominant positive signal over all deforested area due to an increase in the sensible heat flux and a reduction in the evapotranspiration.

• The extreme indices analysis shows increase in HWD, CDD and R95, implying a regime shift towards more intense, less frequent rain events and increasing risk of heat wave in LUCexp.

• These last results also show a remotely effect of extreme indices over other regions in SA continent.
OBRIGADA!
Heat Wave Day Index (HWD): number of heat wave days, where a heat wave occurs when for at least $N_d$ consecutive days the daily maximum temperature exceeds the long term average at least $N_t$ degrees.

Maximum Consecutive Dry Day index (CDD): Maximum number of consecutive dry days, where a dry day is defined as having precipitation below 1 mm/day.

Heavy Precipitation Index (R95): Fraction of precipitation above the 95th intensity percentile, R95.