Land cover change effect on climate in the Central Gulf Coast of Mexico

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1. Introduction

Land cover change (LCC) modifies the energy, momentum and moisture fluxes between land surface and the atmosphere. At local and regional scale, biogeophysical processes, linked to changes in albedo, evapotranspiration and roughness, have a key role on climate [1,2].

The Central Gulf Coast of Mexico is the historically largest deforested region in Mexico, mainly through conversion of forest to grasslands and crops that currently occupy about 77% of the total area. There is not a measure of the effect that these processes have had on climate in this region.

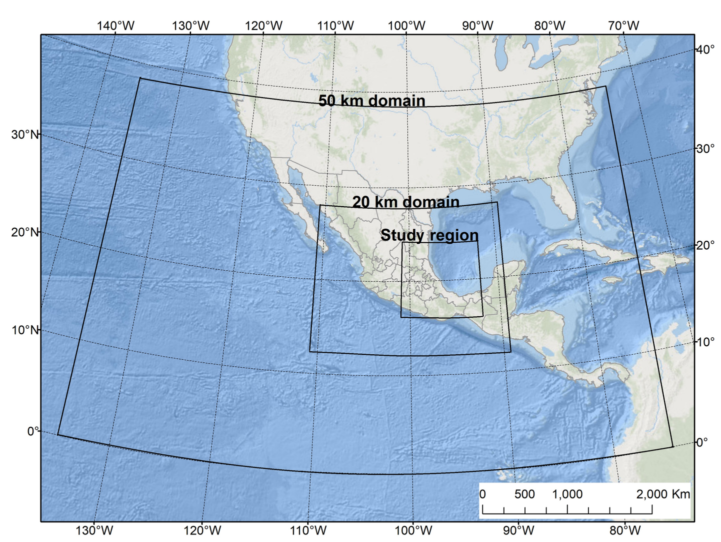
Therefore, we test the sensitivity of climate to LCC:

- Using a Regional Climate Model.
- Improving the model's biosphere-atmosphere transfer scheme, by the adoption of the official land cover of Mexico ([3]), for different years.
- Identifying the seasonal response of temperature and precipitation to changes in biogeophysical processes at land surface level.

2. Methods

2.1 Experiment design

We use RegCM4.3 model with the most recommended configuration for the region.



The BATS scheme represents the physical processes in the surface. ERA-Interim reanalysis [4] and ERSST analysis [5] are used as initial and boundary conditions.

Periods of analysis → 1997-1998: drier than normal
2013-2014: wetter than normal

2.2 Model evaluation

CRU [6] for surface temperature
CHIRPS [7] for precipitation

2.3 Land cover substitution

With the same atmospheric conditions, we run the model with different land covers: *predetermined, 1980, 2010 and Primary Vegetation (undisturbed).*

2.4 Calculation of differences

With the subtraction of the outputs we determine the increase or decrease of the variables, due to LCC.

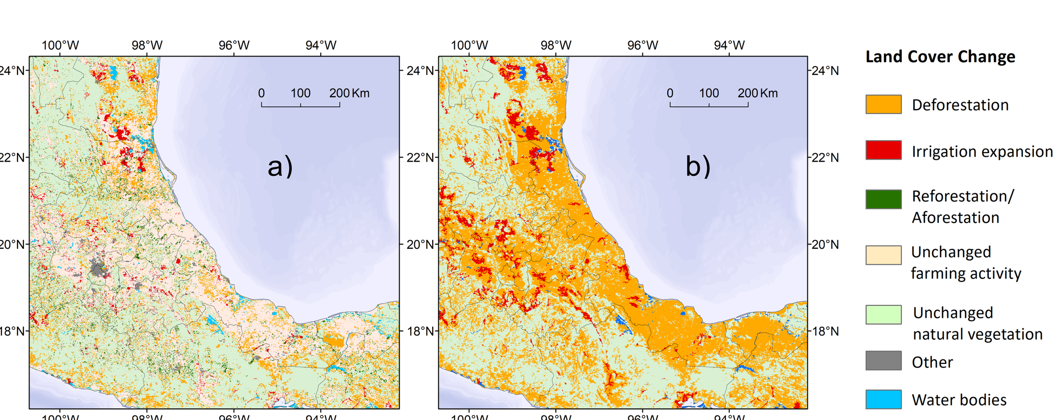
2.5 Surface energy budget

We calculate the surface energy budget for most relevant land covers, to determine the main drivers of the results.

3. LCC in the Central Gulf Coast of Mexico

a) LCC from 1980 to 2010: localized deforestation in the north, center and south of the region. Irrigation growth in the north.

b) LCC from Primary Vegetation to 2010: more extended deforestation and irrigation growth.



4. Response of temperature and precipitation to LCC in a dry year

Deforestation coincides with temperature increase (0.5 to 1.5°C), with a stronger warming in more extended areas of change. This is more evident during the wet season (May to October), where the change in evapotranspiration is larger.

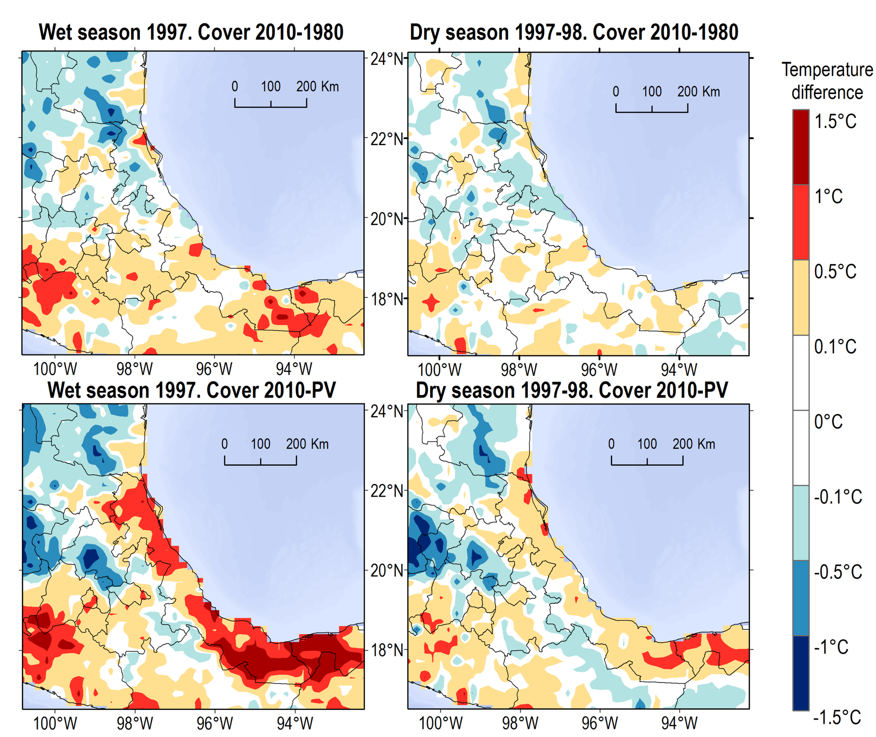
Irrigation growth had a general cooling effect (-0.5 to 1.5°C). This could be explained for the addition of water that increases evapotranspiration and, thus, latent heat flux.

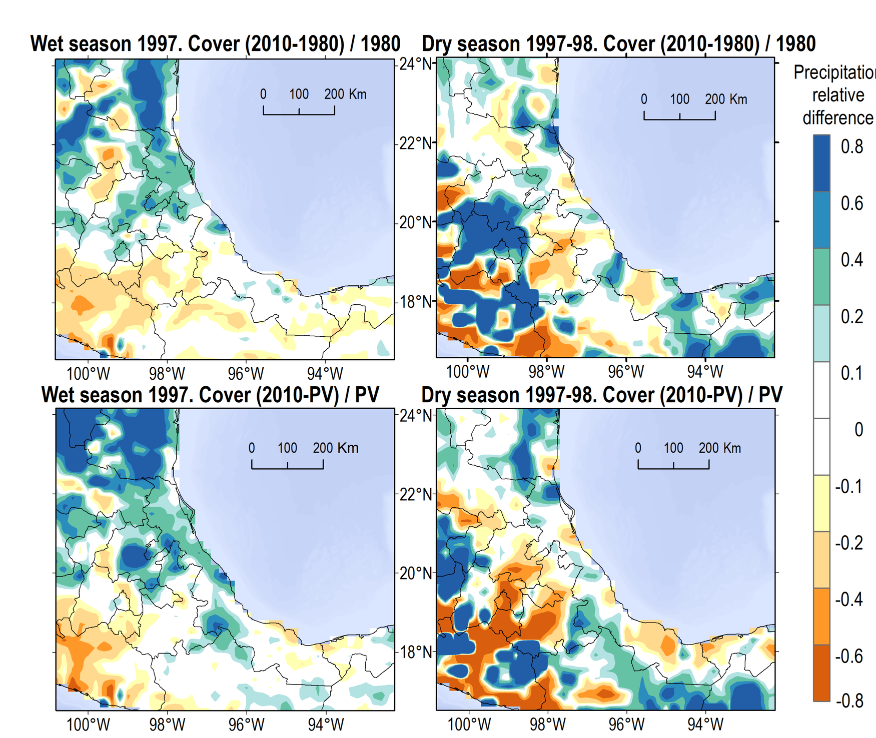
The results in precipitation showed more uncertainty. However, it is possible to associate a precipitation increase of 20%-60% (about 100 to 500 mm) with irrigation growth.

Decrease in precipitation with deforestation, found in similar studies [8,9], is not clear in this study.

$\Delta T_1 = T_{2010} - T_{1980}$ $\Delta T_2 = T_{2010} - T_{VP}$

$\Delta Pr_1 = \frac{Pr_{2010} - Pr_{1980}}{Pr_{1980}}$ $\Delta Pr_2 = \frac{Pr_{2010} - Pr_{VP}}{Pr_{VP}}$



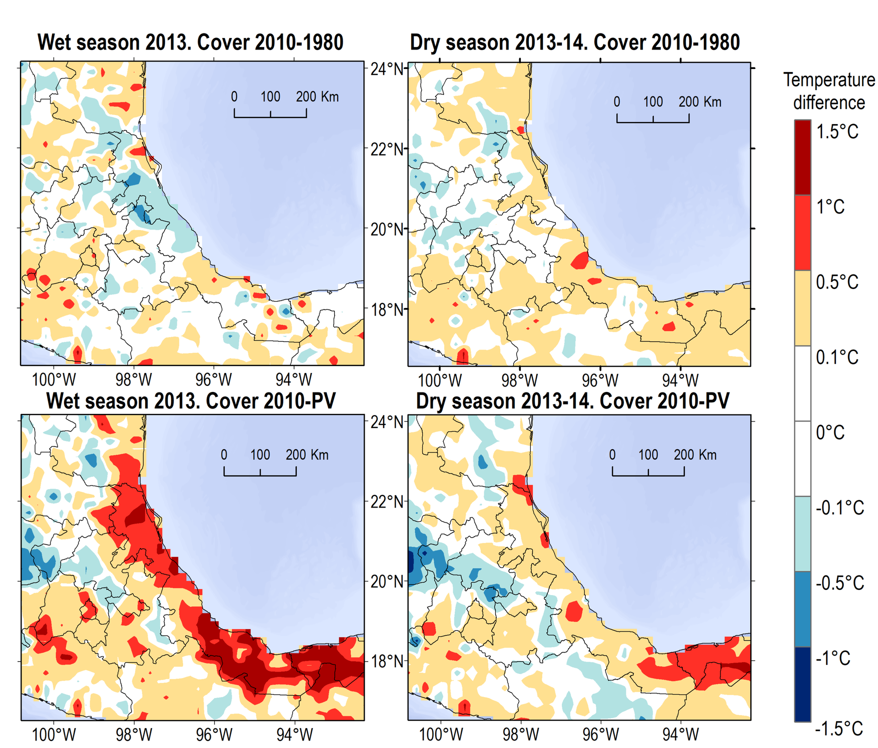


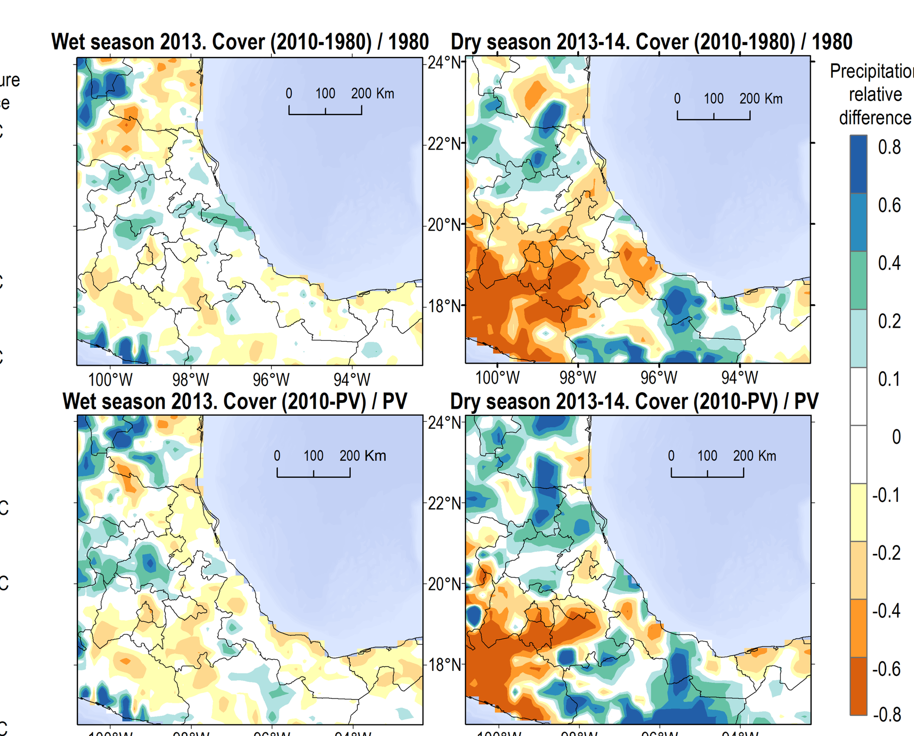
5. Response of temperature and precipitation to LCC in a wet year

Results in temperature were similar in the wet year for deforested areas, despite that the temperature decrease, associated to irrigation, was less intense. This is probably because the more humid conditions reduce the contribution of water from irrigation.

The increase in precipitation, associated with irrigation, is not as large as in the dry year. There is a more extended decrease in precipitation.

The change in surface roughness affects the horizontal advection of moisture and reorganize convection, but there is not a consistent response.

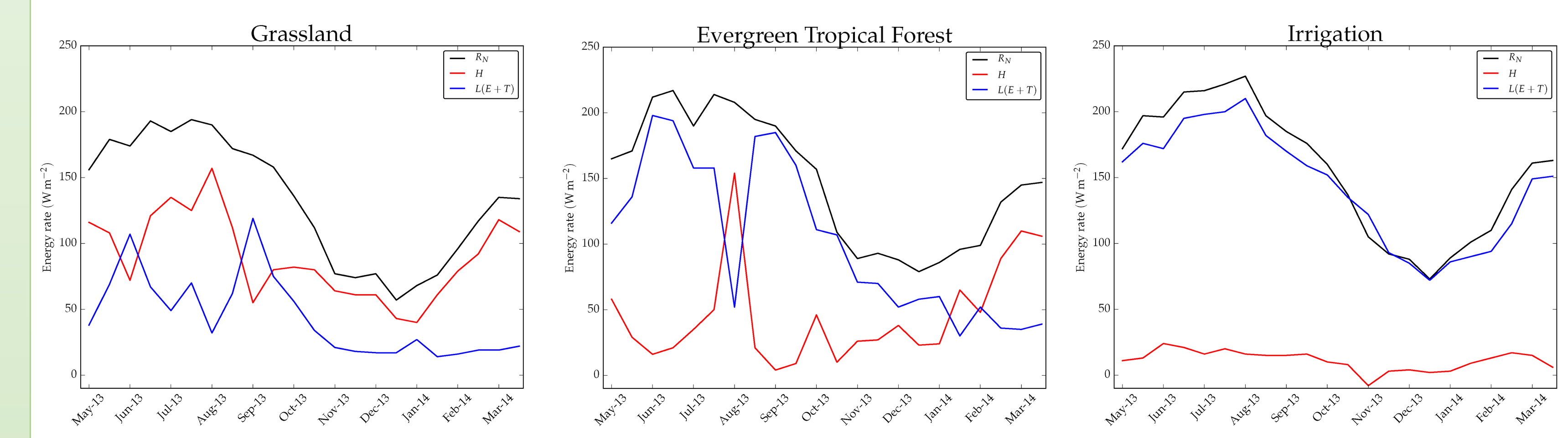




6. Surface energy budget

The total amount of energy in the surface ($R_N = Q_S(1-A) - Q_{LW}^{\uparrow} + Q_{LW}^{\downarrow}$) is greater in Evergreen tropical forest, due to a smaller albedo A. However, this has lesser impact on temperature and precipitation than the change in latent $L(E+Tp)$ and sensible H heat fluxes. Soil heat flux Q_G is negligible for this timescale.

$$Q_G + H + L(E+Tp) = Q_S(1-A) - Q_{LW}^{\uparrow} + Q_{LW}^{\downarrow}$$



7. Conclusions

- **RegCM** represents adequately the temperature and precipitation patterns of the region and it showed a **response** to **INEGI's** LCC.

LCC	Most evident ΔT	Most evident ΔPr
Deforestation (from forest to grassland)	Increase (wet season)	Change
Irrigation growth	Decrease (dry year)	Increase (dry year)

- One of the main drivers of these results is the **evapotranspiration**. However, some of the spatial patterns of the precipitation hint that the **roughness** has a role in the reorganization of convection.
- The geographical **extent** of the change from Primary Vegetation to 2010 land cover intensified the temperature increase. In precipitation, this is not evident.

Future work:

- Use the non-hydrostatic version of the model (**RegCM4.6**) or **WRF** model for higher resolution runs with **explicit convection**.
- Make **ensembles** for more years and/or different initial conditions.
- The results could be used for regional **management** of agricultural and forestry resources to **mitigate** tendencies of temperature and precipitation, in a climate change context.

8. References

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