Desertification processes associated with pasture in Chile for present and future climate

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.Introduction:

The Chilean arid, semi-arid and sub-humid zone presents serious problems associated with desertification processes. The region is characterized by a precipitation concentrated in a few months, with long dry periods during the year, and a high climatic variability, associated mainly to the "El Niño, Southern Oscillation" phenomenon[3]. Due to this variability, there are very dry and wet years, favoring the water erosion in the area. In addition, the region has been historically over exploited by different human activities, such as mining, agriculture and livestock. In northern and central Chile, the climate may have different roles in accelerating desertification. First by the tendency to decreasing rainfall during the 20th century and in the early 21st century, second by the increase in rainfall variability and the intensity, increasing its erosive effect.. Besides this, climate projections indicate a more aggressive climate in the future, contributing to the soils and ecosystems degradation[6]. The main objective of this work is to seek a better understanding of the desertification processes associated with pasture in different dry regions of Chile, and to investigate possible changes in these mechanisms under future climate projections.

2. Arid, semi-arid and sub-humid dry areas of Chile

According to the aridity index, the Chilean arid, semi-arid and sub-humid areas are located between Coquimbo (IV region) and Maule (VII region) as shown in Figure 1.

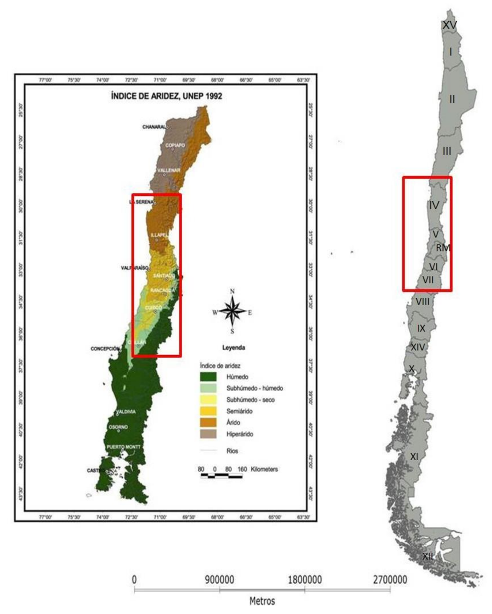

Figure 1. Chilean aridity index[2] and regions. Red box shows study area. Desertification in Chile.

3. Methodology

The methodology is divided in two parts: i) present evaluation (figure 5a) and ii) future evaluation (figure 5b).

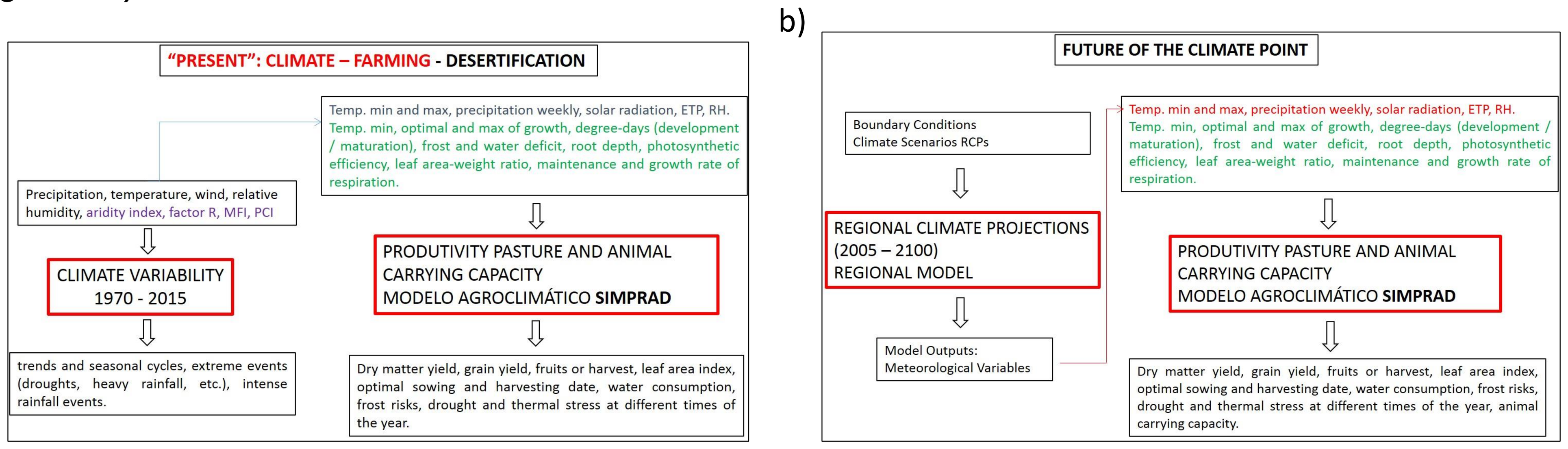

Figure 5. a) Diagram methodology – present evaluation. b) future evaluation.

4. Regional projections

The RegCM (Regional Climate Model System) model of ICTP (International Center for Theoretical Physics), will be used to obtain climate changes in the region.

1. For the boundary condition, the best CMIP5 MCGs will be chosen by comparing some of them with observations and reanalysis for the period 1979 to 2005.

2. In order to project the regional changes in the climate, the RCPs (Representative Concentration Pathways) for the period 2005 to 2100, will be used.

Preliminary Results

Precipitation of 3 MCGs was compared with CRU (Climatic Research Unit) observed datasets and shows good correlation (figure 6).

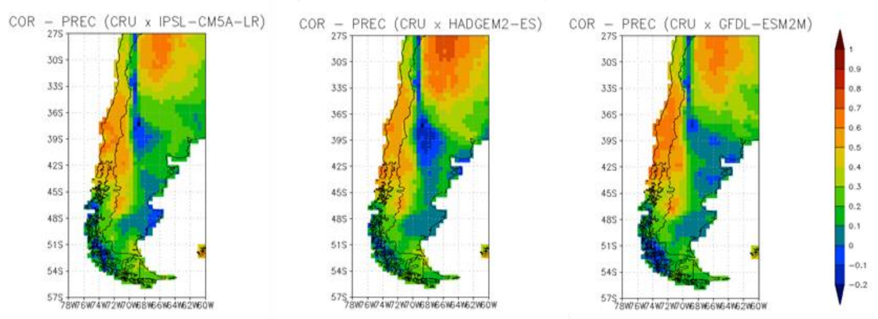

Figure 6. Precipitation correlation between models (HadGEM2, IPSL_CM54_LR, MPI_ESM_ME) and CRU observations (1961-2004).

6. Bibliography

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2.1. Arid, semi-arid and sub-humid dry areas of Chile

The Chilean dry zones are characterized by the Eastern South Pacific Anticyclone (APSO) predominance (Figure 2), which are northward shifted in the austral winter and southward in the austral summer. In winter, the displacement of the APSO to the north allows cold fronts associated with migratory cyclones, contributing to the precipitation in the region. Another system responsible for 5-10% of the total precipitation are the cutoff lows[5], which are associated with intense precipitation events. During the summer, the southward APSO blocks the fronts entrance and, also, increases the temperature, partly due to the associated subsidence. APSO is also associated with intense and predominantly southern winds on the coast.

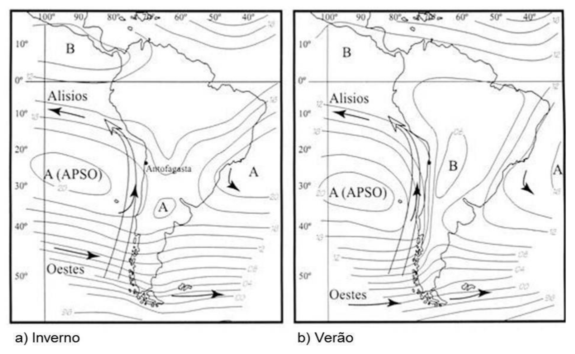

Figure 2. Mean atmospheric pressure at sea level for a) austral winter (June, July and August) and b) austral summer (December, January, February) for South America (Vargas et al., 2000).

The El Niño, Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO) and Antarctic Oscillation (AA) explain most of the inter-annual precipitation variability in central Chile[3]. In its negative phase, El Niño, the precipitation increases (quantity and / or intensity above normal). In the positive phase, "La Niña", precipitation decreases considerably (intense droughts)[4]. This relation is showed in figure 3.

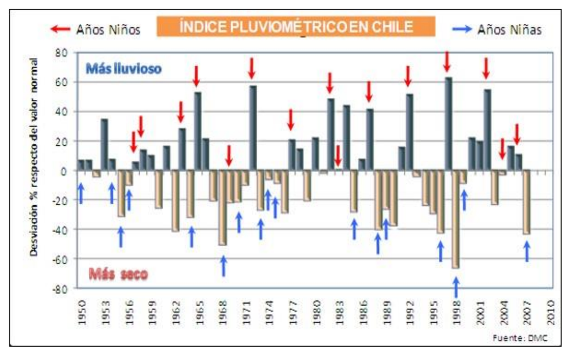

Figure 3: Rainfall anomaly in Chile. Red arrows indicate El Niño and blue La Niña. Fonte: Meteorological Direction of Chile (DMC)

The topography is also very important. The Andes (with height of up to 5000 meters in the study area) and the Costa mountains (heights around 2000 meters) have can increase precipitation by orographic effect and also influence temperatures and wind[1]

Currently, 22% of the surface of Chile has some degree of desertification, corresponding to 16,379,342 hectares, with a population of 31.9% (figure 4). The main causes of desertification in Chile are droughts, deforestation, forest fires, land use change processes and inadequate use of agriculture and livestock. Mining is also a contributing factor to the processes of desertification[4].

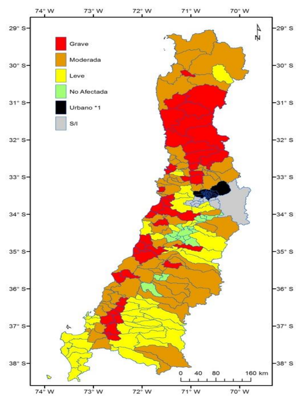

Figure 4: Desertification in Chile

5. SIMPRAD model

The model simulates the growth of the pasture and the animal carrying capacity, based on the incident solar radiation, temperature and of water availability.

Preliminary results show that the variation in productivity is proportional to precipitation. The El Niño years, increased rainfall, productivity would be higher than in the La Niña years, when there is a decrease in precipitation (figure 7a and b).

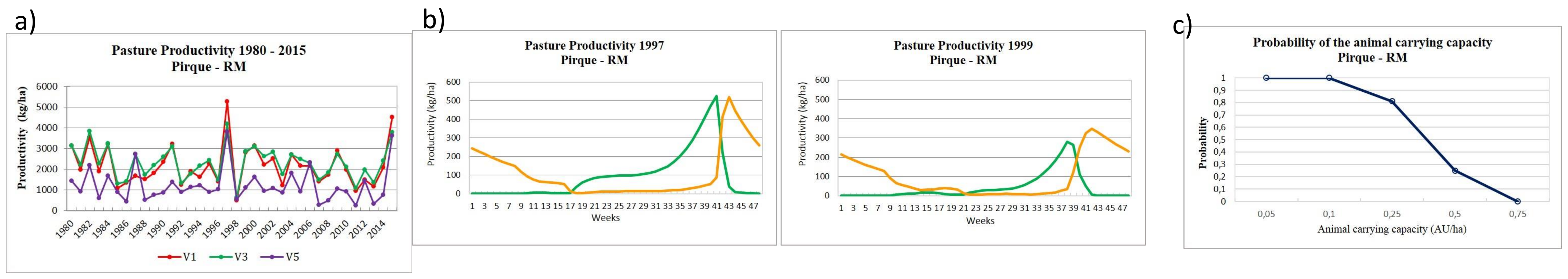

Figure 7. a) Pasture productivity for the period 1980 -2015. V1, V3 and V5 represents different types of pastures. b) Pasture productivity 1997 e 1999. Green line: Pasture green, brown line: Pasture dry. c) Probability of the animal carrying capacity.