Abstract. Palynological, geomorphological, and relict vegetation evidence point to the existence of cooler and more humid conditions along semiarid and temperate Chile during the Pleistocene. Departing from an actualistic model, and utilizing a regression technique that includes significant independent variables on the basis of $R^2$ and $F$ statistics, the best fit multivariable model was produced for annual rainfall and snowline elevation. Predicted values for rainfall are obtained by controlling sea surface temperatures and air temperatures (the most significant variables in the model) at different latitudes. A variation of only 1°C of the winter sea and air temperatures induces more than a doubling of the annual precipitation in north-central Chile, and increases by nearly fifty percent in southern Chile. Entering the predicted values of precipitation and lowering the winter temperatures by 1 or 2°C produces a slight depression of the snowline in semiarid north-central Chile and a significant descent in southern Chile. The predicted depression of the snowline coincided well with geomorphological evidence of glacial advances and fossil periglacial phenomena in the Andes. Cooling and increased precipitation during the Pleistocene pluvial elicited northward shifts of the temperate rainforest of southern Chile in the order of 7 deg latitude.

1. Introduction

In recent years, several attempts at recreating climatic and vegetational patterns by using palynological techniques have been made in central and southern Chile with varying degrees of success (Heusser and Streeter, 1980; Heusser, 1981; Heusser, 1983; Porter, 1981). From the palynological records inferences have been made about the thermal and precipitation conditions that may have prevailed when central Chile was covered by more humid vegetal formations – from 14 500 to 28 100, and 33 300 to 43 600 y B.P., according to Heusser (1983). Other indirect observations of past climatic conditions have been derived from findings of relict temperate rainforest stands, with species such as Drymis wintry (Forster), Aextoxicon punctatum (R. et Pavon), Myrceugenia correfolia (Hook et Arn) as far north as 31°S, at which latitude such forests do not constitute the natural climax vegetation today (Villagrán and Armesto, 1980). Other approaches to palaeoclimatic reconstructions in the country have resorted to observations of the present snowline (Lliboutry, 1956; Hastenrath, 1971) and to the association with geomorphological testimonies left by depressed snowlines during the Pleistocene (Weischet, 1969; Caviedes and Paskoff, 1975: Strecker, 1987).
These contributions have established that, indeed, cooler and more humid conditions existed – at least at the end of the Pleistocene (± 11 380 y. B.P.; Heusser, 1983). However, quantitative assessments of the changes in temperature and humidity have not been attempted, except for the work by Heusser, Streeter and Stuiver (1981). Using regression equations relating contemporary pollen to temperature and humidity at latitudes 41–56° S, they deduced – on the bases of fossil pollen – the climatic conditions of southern Chile from the Holocene to 43 000 years B.P.

The climatic models that have been proposed to back palynological or geomorphological findings are often of discursive or speculative nature and unsuitable for scientific testing. It is, therefore, the purpose of this article to apply an actualistic model in order to infer the characteristics of the coastal climate of Chile during the cold-humid periods of the Quaternary, and to fit Pleistocene snowline and vegetal patterns to the resulting climatic reconstructions. A multiregressive model has been adopted with this aim. Although the limitations of such a deterministic model are recognized in advance, the possibility of comparing modelled climatic parameters with vegetation and geomorphological evidences from the past make the exercise worthwhile.

Some interesting precedents justify the utilization of multi-regressive models to recreate past conditions by controlling determinant climatic variables. The CLIMAP experiment (1976), the simulation of Ice-Age climate in July by Gates (1976), the work by Molina-Cruz (1977) on modelling wind circulation and coastal upwelling in western South America, and the contribution of Heusser, Streeter and Stuiver (1981) in reconstructing climatic conditions from pollen records are good examples of the application of multiregressive methods to climate reconstructions.

2. Present Climatic Conditions as Basis of the Actualistic Model

Several physical features of central and southern Chile make viable the use of actualistic models and their projection into the past. First, the physiographic units of the country – coastal plains, coastal ranges, central depression, and Andes mountains – are almost rectilinear and parallel to each other (Figure 1). Thus, with increasing latitude there is an almost linear decrease of air temperatures, an increase of precipitation, and a lowering of the snowline. Second, the exposure of central and southern Chile to maritime influences, to seasonal shifts of winds, and to the polar front is felt along the coast and in the high mountains almost undisturbed by physical obstacles. Third, the maritime effects are enhanced by the cooling influence of the Peru (Humboldt) Current in front of the Chilean coast. Consequently, sea surface temperatures along the Chilean coast decrease also almost linearly, from north to south and the air temperature regime along Chile reproduces well the latitudinal changes of sea temperatures. Fourth, from the northern border of Chile (17.5° S) to almost the end of continental Chile (42° S), the dominating W, SW, and S winds, and also the coastal upwelling, are directly linked to the