TREE-RING AND GLACIAL EVIDENCE FOR THE MEDIEVAL WARM EPOCH AND THE LITTLE ICE AGE IN SOUTHERN SOUTH AMERICA

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Abstract. A tree-ring reconstruction of summer temperatures from northern Patagonia shows distinct episodes of higher and lower temperature during the last 1000 yr. The first cold interval was from A.D. 900 to 1070, which was followed by a warm period A.D. 1080 to 1250 (approximately coincident with the *Medieval Warm Epoch*). Afterwards a long, cold-moist interval followed from A.D. 1270 to 1660, peaking around 1340 and 1640 (contemporaneously with early *Little Ice Age* events in the Northern Hemisphere). In central Chile, winter rainfall variations were reconstructed using tree rings back to the year A.D. 1220. From A.D. 1220 to 1280, and from A.D. 1450 to 1550, rainfall was above the long-term mean. Droughts apparently occurred between A.D. 1280 and 1450, from 1570 to 1650, and from 1770 to 1820. In northern Patagonia, radiocarbon dates and tree-ring dates record two major glacial advances in the A.D. 1270–1380 and 1520–1670 intervals. In southern Patagonia, the initiation of the *Little Ice Age* appears to have been around A.D. 1300, and the culmination of glacial advances between the late 17th to the early 19th centuries.

Most of the reconstructed winter-dry periods in central Chile are synchronous with cold summers in northern Patagonia, resembling the present regional patterns associated with the El Niño-Southern Oscillation (ENSO). The years A.D. 1468–69 represent, in both temperature and precipitation reconstructions from tree-rings, the largest departures during the last 1000 yr. A very strong ENSO event was probably responsible for these extreme deviations. Tree-ring analysis also indicates that the association between a weaker southeastern Pacific subtropical anticyclone and the occurence of El Niño events has been stable over the last four centuries, although some anomalous cases are recognized.

1. Introduction

Paleoclimatic studies in the Southern Hemisphere have historically lagged those of the Northern Hemisphere. Recent Holocene records for the Southern Hemisphere, (particularly from South America), are comparatively rare. However, for a global interpretation of climate variations at any time scale, there is a need to examine and incorporate the records from the Southern Hemisphere.

In the Northern Hemisphere, the two most significant climatic events recognized during the last millennium are the *Medieval Optimum* and the *Little Ice Age*. The evidence for the *Medieval Optimum* period is mainly from Europe and the North Atlantic (Lamb, 1977; Williams and Wigley, 1983). A clear definition for the timing

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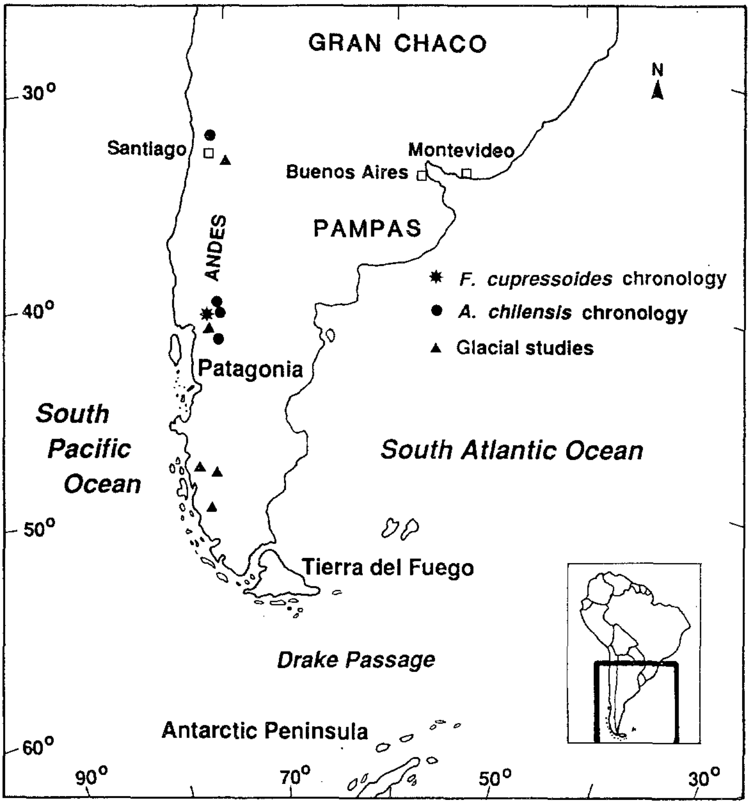

Fig. 1. Location map of tree-ring and glaciological records in southern South America.

and character of this period is not available on a global basis. Historical evidence of the *Little Ice Age* events is much more complete in Europe than elsewhere, but its expression in other continents is supported by much field evidence (Grove, 1988).

Southern South America (Figure 1), the only continental land mass in the Southern Hemisphere extending as far south as 55°S, presents a unique opportunity to reconstruct terrestrial records of paleoclimate in a region that is under the influence of polar and mid-latitude atmospheric circulation features (Taljard, 1972). This paper provides an overview of the most significant climatic fluctuations in southern South America during the last 1000 yr derived from tree-ring records and other paleoclimate indicators. Because no global consensus exits for the dates of the *Medieval Optimum* and the *Little Ice Age* events, Lamb (1977) dates, largely based on European evidences, are used here as temporal references only.

Climatic studies using modern instrumental records (i.e. over the past c. 100 yr) indicate that the South American climate is strongly affected by warm and cold events associated with the Southern Oscillation (SO) (Aceituno, 1988; Kiladis and Diaz, 1989). Consistent changes in the regional patterns of temperature and precipitation in South America associated with SO, provide the climatological