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Dominant Factors Controlling Glacial and Interglacial Variations in the Treeline Elevation in Tropical Africa

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Pollen data show a lowering of tree-line elevations during the Last Glacial Maximum (LGM) by about 1000 to 1700 m in mountains at a wide range of tropical and subtropical locations. Assuming a lapse rate of 5 to 6˚C km-1, this implies a cooling of about 5 to 10˚C. This cooling is larger than this inferred by pollen transfer function (Bonnefille et al., 1990) and by marine data (Kurcera et al, 2005). Farrera et al (1999) have shown that the lapse rate, possibly lower during the LGM, could be partly responsible of this discrepancy. In addition, we know that carbon and water uptake in plants are highly dependent on CO_2 concentrations. In particular, under low CO_2 concentrations, the water use efficiency of the plants is lower than at present under much higher CO_2 concentration. Climate reconstruction cannot be only based on transposition of modern situations. Mechanistic models, able to take into account the major processes of plant ecophysiology, must be used to better understand the interactions between plant distribution and climate. So Jolly and Haxeltine (1997) have shown that low atmospheric CO_2 concentration could by itself cause the observed replacement of tropical mountain forests by scrub during the LGM, suggesting that previous pollen-based estimates of temperature decreases during the LGM have been overestimated. Then, a method of climate reconstruction based on process-based modelling has then been devised to provide a solution not too much related to modern conditions (Guiot et al, 2000). This method, based on inverse BIOME4 vegetation model, has been improved by Wu et al (2007a) who showed effectively a bias in the reconstructions when modern CO_2 level are used instead of LGM level. They applied the method to Eu-

rope, Siberia and Africa. Focusing on the tree-line (Wu et al, 2007b), we devised a series of sensitivity experiments to estimate the effects of temperature, precipitation, and atmospheric CO_2 concentration on changes in the tree-line elevation based on a set of pollen data covering an altitudinal range from 100 to 3,140 m asl in Africa. We show that lowering of the tree-line during the LGM was primarily triggered by regional drying, and was amplified by decreases in atmospheric CO_2 concentration and temperature. This result contrasts with scenarios for the Holocene and future climates, in which the increase in treeline elevation is dominated by temperature. Our results suggest that previous climate changes inferred from tree-line shifts may have been overestimated for low-CO_2 glacial periods because the limiting factors that control changes in the elevation of the tree-line differ between glacial and interglacial periods.

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