



## **Dendroglaciological investigation on debris-covered glaciers and GIS application: the case of Miage Glacier (Western Italian Alps)**

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The Miage Glacier (Aosta Valley, Italy) is the most important debris-covered glacier in the Italian Alps. The lower part of its tongue is colonised by trees (mainly European larch), shrubs and herbaceous vegetation. Supraglacial trees react to glacier sliding and to vertical movements related to freezing and melting processes assuming characteristic shapes. Moreover, tree rings record the debris instability related to the ice sliding down-valley, the transmission of kinematic waves and glacio-karst phenomena. A dendroglaciological analysis carried out on the larch population growing on the glacier and on reference chronologies from outside the glacier, has allowed the identification of the temporal distribution of the growth disturbances (event years, pointer years, compression wood and abrupt growth changes) in supraglacial trees. The results showed the passage of a kinematic wave that reached first the southern lobe and few years later the northern lobe as demonstrated by the concentration of indicators of growth disturbance: in the northern lobe they mainly occurred in the period 1989-1993 (5 years), while in the southern lobe in the period 1984-1990 (7 years). The time lag and the time span between the growth-disturbance signals from the two lobes suggest that the kinematic wave which crossed the glacier tongue in the 1980's seems to have been slower and weaker on the northern lobe. Supraglacial trees move progressively down-valley according to glacial sliding. The young age of trees (never older than 60 yr), is controlled by glacier movement and by backwasting and downwasting processes on the ice cliffs opened along the tongue margin. Downwasting

processes diminish the ice-cliff slope, also inducing its burying, while backwasting processes allow the ice cliffs to continue their retreat causing a tree lost estimated in about 150 individuals, including saplings. (data related to summer 2006). In this study, geographic information systems have been used to improve dendroglaciological method, using spatial data analysis to investigate surface movements of Miage Glacier. Data collected have been stored in a relational database designed for dendrochronological analysis. The integration between classical dendroglaciological analysis and GIS elaboration allows to deepen investigate spatial and temporal data stored in different layers, determining relations between supraglacial trees distribution and the debris cover. Combining this two kinds of analysis allows to link growth anomalies and abrupt growth changes to glacier tongue morphologic characteristics and to debris cover movements. GIS elaborations permitted also the visualization of dendrochronological results in different thematic maps representing sampled trees and characters of surrounding areas. Our results confirm the importance of supraglacial trees as a useful marker of the present debris covered glacier dynamics and shrinkage at the tongue.