Geophysical Research Abstracts
Vol. 19, EGU2017-870, 2017
EGU General Assembly 2017
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Soils evolution and treeline fluctuations under late Holocene climatic changes: an integrated approach from Valle d'Aosta (Western European Alps, Italy)

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The treeline ecotone, defined as the transition belt in mountain vegetation between the closed forest (timberline) and the alpine grasslands, is one of the most distinctive features of mountain environments and it is widely considered as a climatic boundary. Treeline altitudinal fluctuations may be considered to assess past and ongoing climatic and environmental changes. Although the ecological dynamics of the alpine treeline ecotone is mainly influenced by climate, especially by soil temperature, climatic parameters are not the only factors that influence the treeline position. In fact, the treeline altitude may be locally influenced by environmental factors, geomorphological processes, soil development, and human activities.
This study aims at the reconstruction of late Holocene soil evolution and environmental changes at the treeline on the SW slope of the Becca di Viou Mountain in Valle d'Aosta (Western Italian Alps).
First, we performed a detailed reconstruction of the treeline altitudinal dynamics. In addition, field (including air and soil temperatures) and laboratory (of both mineral and organic compounds) characterizations have been performed along two transects of seven soil profiles developing at an altitude ranging from 2100 m a.s.l. (closed forest) to 2400 m a.s.l. (treeline ecotone), in order to understand the relationships between colonization by trees and soil development under the ongoing climate change.
The upward shift of the treeline was assessed analyzing tree age distribution along the slope by means of a tree-ring based approach. The reconstruction of the treeline altitudinal dynamics (based on years at which the trees reached 2 m in height) at the study site reveals an upward shift of 115 m over the period 1901–2000, reaching the altitude of 2515 m a.s.l. in 2008. The recent treeline shift and the acceleration of tree colonization rates in the alpine belt can be mainly attributed to a climatic input, and particularly to an increasing temperature.
The investigated soils show a decreasing development with increasing altitude. Indeed, in the forest area (about 2100 m a.s.l.) soils are well developed (i.e. Podzol), but at higher altitude, they are less developed (i.e. Ranker). In the treeline ecotone, possible traces of Paleosols are also observed.
However, future treeline upward shifts in the study area might be severely limited by the geomorphic processes: even if temperature will continue to increase, at higher altitudes, the treeline will meet harsher geomorphic environments characterized by high-energy gravity processes and rock faces that impede soil evolution and tree colonization.
The integrated analysis of geopedological, dendrochronological and climate data will provide high resolution information about the responses of high-altitude biological and abiological systems through the Holocene and to the ongoing climate change.