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Climatic Drivers of Greening Trends in the Alps

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Since the 1980s, vegetated lands have experienced widespread greening at the global scale. Spatial patterns and mechanisms of this phenomenon were extensively investigated, especially in the Arctic and sub-Arctic regions. Greening trends in the European Alps have received less attention, although this region has experienced strong climate and land-use changes during recent decades. We investigated the rates and spatial patterns of greening in an inner-alpine region of the Western Alps. We used MODIS-derived normalized difference vegetation index (NDVI) at 8-day temporal and 250 m spatial resolution, for the period 2000–2018, and removed areas with disturbances in order to consider the trends of undisturbed vegetation. We had two objectives :

(i) quantify trends of greening in a representative area of the Western Alps; and (ii) examine mechanisms and causes of spatial patterns of greening across different plant types.

Sixty-three percent of vegetated areas experienced significant trends during the 2000–2018 period, of which only 8% were negative. We identify (i) a climatic control on spring and autumn phenology with contrasting effects depending on plant type and elevation, and (ii) land-use change dynamics, such as shrub encroachment on abandoned pastures and colonization of new surfaces at high elevation.

Below 1500 m, warming temperatures promote incremental greening in the transition from spring to summer, but not in fall, suggesting either photoperiod or water limitation. In the alpine and sub-alpine belts (> 1800 m asl), snow prevents vegetation development until late spring, despite favorable temperatures. Instead, at high elevation greening acts both in summer and autumn. However, photoperiod limitation likely prevents forested ecosystems from fully exploiting warmer autumn conditions. We furthermore illustrate two emblematic cases of prominent greening: recent colonization of previously glaciated/non vegetated areas, as well as shrub/tree encroachment due to the abandonment of agricultural practices. Our results demonstrate the interplay of climate and land-use change in controlling greening dynamics in the Western Alps.