

Observed long-term greening of alpine vegetation ? a case study in the French Alps

We combined imagery from multiple sources (MODIS, Landsat-5, 7, 8) with land cover data to test for long-term (1984-2015) greening or browning trends of vegetation in a temperate alpine area, the Ecrins National Park, in the context of recent climate change and domestic grazing practices. We showed that over half (56%) of the Ecrins National Park displayed significant increases in peak normalized difference vegetation index (NDVI_{max}) over the last 16 years (2000-2015). Importantly, the highest proportional increases in NDVI_{max} occurred in rocky habitats at high elevations (> 2500 m a.s.l.). While spatial agreement in the direction of change in NDVI_{max} as detected by MODIS and Landsat was high (76% overlap), correlations between log-response ratio values were of moderate strength (approx. 0.3). In the context of above treeline habitats, we found that proportional increases in NDVI_{max} were higher between 1984 and 2000 than between 2000 and 2015, suggesting a slowing of greening dynamics during the recent decade. The timing of accelerated greening prior to 2000 coincided with a pronounced increase in the amount of snow-free growing degree-days that occurred during the 1980s and 1990s. In the case of grasslands and low-shrub habitats, we did not find evidence for a negative effect of grazing on greening trends, possibly due to the low grazing intensity typically found in the study area. We propose that the emergence of a longer and warmer growing season enabled high-elevation plant communities to produce more biomass, and also allowed for plant colonization of habitats previously characterized by long-lasting snow cover. Increasing plant productivity in an alpine context has potential implications for biodiversity trajectories and for ecosystem services in mountain landscapes. The presented evidence for long-term greening trends in a representative region of the European Alps provides the basis for further research on mechanisms of greening in alpine landscapes.

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