Annual variations in snowmelt timing and phenology of green-up and autumnal color for alpine plants at Tateyama Murodo and Senjojiki

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Introduction: In alpine ecosystems existing isolated under severe cold climate, due to recent accelerated global warming, changes in their habitat and phenology, such as green-up, flowering, autumnal leaf color and fall, have been reported. In addition, because of different environmental responses, mismatch of life cycles occurs between plants and insects or animals. Alpine ecosystems are particularly vulnerable to the effect of climate change, and the necessity for monitoring of alpine ecosystems is recognized. The snow fall and snow melt are the key factors for the growth of alpine plants in Japanese alpine zone. We have launched continuous monitoring of snowmelt timing and vegetation phenology in Japanese alpine ecosystems by using automatic time-lapse camera. In this present study, our objectives are to derive the spatial and temporal variations of both snowmelt timing and phenology at a local scale by means of image analysis. And then we investigate and clarify the relationships of the phenology and meteorological factors.
Methods: We set up time-lapse cameras at Tateyama Murodo (2450m a.s.l) in Japanese Northern Alps and at Senjoujiki (2650m a.s.l) in Japanese Central Alps. About 18000 and 11000 images captured with each camera, respectively, were used for analysis. RGB digital counts were derived from each pixel within JPG format images. The snow-cover and snow-free pixels were statistically classified, spatial and temporal patterns of snowmelt were investigated. For further quantitative assessment for the phenology of green-up and autumnal leaf and the brightness of autumn leaf color, time-series of the ratios of Green and Red against the sum of RGB were calculated, respectively, as indices for greenness and redness, within the areas of two specific alpine plants (*Sorbus matsumurana* and *Betula ermanii*) captured in images.
Results: During the winter season in 2015-2016, as snowfall was the least in these few years and the temperature was relatively high, the snowmelt timings were approximately 22 and 38 days faster than usual, respectively, at Murodo and Srnjojiki. The fastest snowmelt attributed the fastest green-up dates and the longest growing periods among these few years. The annual variations of autumnal leaf color timing were usually strongly correlated to the average temperature during late August to mid-September, however that in 2016 was irregularly faster despite high temperature. Therefore, we predicted the autumnal leaf timing by a regression formula with green-up date in addition to average temperature for explanatory factors, taking account of leaf longevity. The brightness of the autumnal color was relatively lower in 2016 at both sites. We found the relationships between annual variations of the brightness and the amount of solar radiation during summer and also large decline in minimum temperature in September. Monitoring alpine ecosystems using time-lapse cameras allowed us to track the snowmelt timings and plants phenology at high temporal and spatial resolutions, and to compare them quantitatively at multiple sites and times as well. Further research using meteorological data will make progress in assessment of affects and prediction of phenology under future climate change.

Keywords: Time-lapse camera, Image analysis, RGB, Leaf longevity, Brightness of autumnal leaf color

