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# Influence of early snowmelt on phenology and ecosystem productivity of an unmanaged mountain grassland of northwestern Italian Alps

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Mountain regions are expected to be particularly influenced by future climate change with increasing temperature, change in precipitation patterns and duration of snow cover. In particular climate change is foreseen to impact alpine ecosystems by increasing of weather extremes (e.g. heat waves, droughts, exceptional anticipated snowmelt). Although different studies attested the effect of climate change on vegetation phenological shifts, uncertainties exist on the impacts of such shifts on ecosystem processes and hence on the ecosystem-climate feedbacks.
High-altitude grasslands are snow-covered for most of the year and act as a net carbon source throughout all the snow period. Little is still known on the effects of spring warming and early snowmelt on annual carbon budget of these alpine ecosystems.
Being part of the PhenoAlp project (www.phenoalp.eu) this study evaluated the effect of an exceptional early snowmelt observed in 2011 on the relationship between plant phenology and the ecosystem functioning of an unmanaged grassland of northwestern Italian Alps located at 2160 m asl. The following main questions were addressed: does an early snowmelt date increase the length of the growing season? If so, what is the effect on the productivity of the ecosystem?
For this purpose continuous measurements of $CO_2$ exchange across the biosphere/atmosphere interface assessed by means of eddy covariance since summer 2008 were evaluated. In order to analyse the relationship between phenology and ecosystem productivity, we extracted phenological indicators from $CO_2$ flux time-series.
Results showed shifts in the phenological indicators considered and a clear effect on the dynamics of the NEE (Net Ecosystem $CO_2$ Exchange) and GPP (Gross Primary Production) time-courses as a consequence of earlier snowmelt. The grassland turned from a source to a sink more than one month in advance compared to previous years. The earlier onset of biological activity was also supported by evaluations of canopy greening, LAI and vegetation indices. Beside this highly anticipated beginning of the growing season, we found a slower general dynamics of carbon flux components and lower summer peaks of NEE and GPP in 2011 compared to previous years, with different implications on the growing season productivity and the annual carbon balance of the grassland.