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Links between spring snow cover and long-term alpine vegetation change

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Snow is an important environmental factor determining distributions of plant species in alpine ecosystems. During the past decades, climate warming has resulted in significant reduction of snow cover extent globally, which led to remarkable alpine vegetation change. Alpine vegetation change is often caused by the combined effects of increasing air temperature and snow cover change, yet the relationship between snow cover and vegetation change is currently not fully understood. To detect changes in both snow cover and alpine vegetation, a relatively fine spatial scales over long temporal spans is necessary. In this study in alpine tundra of the Changbai Mountains, Northeast China, we (1) quantified spatiotemporal changes of spring snow cover area (SCA) during half a century by using multi-source remote sensing datasets; (2) detected long-term vegetation greening and browning trends at pixel level using Landsat archives of 30 m resolution, and (3) analyzed the relationship between spring SCA change and vegetation change. Results showed that spring SCA has decreased significantly during the last 50 years in line with climate warming. Changes in vegetation greening and browning trend were related to distributional range dynamics of a dominant indigenous evergreen shrub *Rhododendron aureum*, which extended at the leading edge and retracted at the trailing edge. Changes in *R. aureum* distribution were probably related to spring snow cover changes. Areas with decreasing *R. aureum* cover were often located in snow patches where probably herbs and grasses encroached from low elevations and adjacent communities. Our study highlights that spring SCA derived from multi-source remote sensing imagery can be used as a proxy to explore relationship between snow cover and vegetation change in alpine ecosystems. Alpine indigenous plant species may migrate upward following the reduction of snow-dominated environments in the context of climate warming and could be threatened by encroaching plants within snow bed habitats.