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Off-season carbon dioxide exchange of a temperate mountain grassland in a warmer future climate

G. Wohlfahrt (1), A. Gobiet (2), A. Hammerle (1), A. Haslwanter (1), L. Hörtnagl (1), Ch. Irschick (1), and M. Themeßl (2)

(1) Institut für Ökologie, Leopold-Franzens Universität Innsbruck, Innsbruck, Austria, (2) Wegener Zentrum für Klima und Globalen Wandel, Karl-Franzens-Universität Graz, Graz, Austria

It is well established that warming leads to an earlier onset and delayed termination of seasonal plant activity in the Northern hemisphere. Whether this goes along with an increase or decrease in the carbon dioxide (CO_2) sink strength of terrestrial ecosystems, however, is much more controversial. We used a simple model that considers temperature and day length to simulate the off-season, i.e. between the end and the start of the carbon uptake period (CUP), CO_2 exchange of a temperate mountain grassland in Austria. The model was calibrated with a 10-year record of eddy covariance CO_2 flux measurements. Our major findings were: The end of the CUP of this managed grassland was determined not by environmental conditions but by the timing of the final harvest, because the temperature response of daytime net carbon uptake in autumn was too weak to compensate for nighttime carbon losses. A critical day length, reached by the end of March, exists below which net carbon gain was impossible on a daily basis. Using five climate scenarios and comparing the periods 1961-1990 and 2021-2050 we were able to show that earlier onsets of the CUP under future warmer conditions (+1.0 to +1.7°C) were by far offset by earlier snow melting dates and thus a lengthening of the period before the critical day length was reached. In total however, off-season losses hardly differed between the two investigated periods, which was due to compensating effects of larger CO_2 losses in autumn and spring and smaller losses during winter. Taken together our study suggests the off-season CO_2 exchange of temperate mountain grasslands to be resilient against climate change scenarios predicted for the middle of the 21st century.