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Older soil organic matter is the main source of soil respiration in winter at the alpine treeline – a 13CO2-tracer study

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Despite low air temperatures in high latitude and altitude ecosystems, soil microbes remain still active under thick insulating snow packs. Thus, winter respiration contributes substantially to annual CO2 effluxes from high latitude and altitude ecosystems. The sources of soil-respired CO2 in winter are, however, uncertain.
At the Swiss alpine treeline near Davos, we have been enriching ecosystems with CO2 being depleted in 13C for eight years. This provided a unique 13C label for recent plant-derived C in the plant and soil system. Winter soil respiration rate was quantified by measuring CO2 gradients in the snow pack. For isotopic analysis, soil-respired CO2 was sampled at the soil surface.
Results indicate that about 25% of the annual CO2 efflux from soils occurred during the seven month long winter. The 13C-tracing reveals substantial changes in the sources of soil-respired CO2 during the year. While approximately 50 to 60% of the respired CO2 originated from recent plant-derived C (root and litter) in the growing season, this fraction accounted only for 20 to 30% of the respiration losses in winter. One reason for the small losses of recent plant-derived C during winter is that plant activity and hence, autotrophic respiration is negligible under the more than 1 m thick snow pack. Another reason could be the temperature profile in soils with frozen litter layer at the soil surface and ‘warmer’ subsoils. Thus, respiratory activity might be higher in deeper soils with older soil organic C.
In summary, our results show that soil respiration in winter contributes significantly to annual CO2 effluxes and is dominated by old C sources. Therefore, respiratory C losses in winter represent a considerable magnitude in the balance of soil organic matter.