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Shrubs are widespread in Snowpacks and Affect Ground Temperature. Models Must Include this Process

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Shrubs covered by snow enhance ground cooling in winter because branches act as thermal bridges between the cold atmosphere and the warmer ground. This process is particularly active in the Arctic, because frozen wood has a thermal conductivity 50 times larger than Arctic depth hoar. Since shrubs are widespread in the Arctic, thermal bridging must be incorporated in snow models for proper simulations of the ground thermal regime, of the temperature gradient in the snowpack, and of snow metamorphism. In alpine regions, the thermal contrast between wood and snow is less than 10 because unfrozen wood has a lower thermal conductivity than frozen wood and because alpine snow is more conductive than Arctic depth hoar. The thermal impact of mountain shrubs may therefore be considered negligible. Measurements of ground temperature and liquid water content at an Alpine site (Lautaret pass, 2050 m, French Alps) with 2 m tall alders next to mountain grasslands surprisingly show that alders do impact noticeably the ground thermal regime. Under grasslands, the ground remains at 0°C and very little ground water freezes. Under alders, most ground water freezes and the temperature drops below -1°C. We perform finite elements simulations to assess the capacity of the alders to act as thermal bridges though two phenomena: the thickness of the alder branches that compensate the lower wood/snow thermal contrast, and protruding branches acting as radiators releasing heat into the atmosphere. We conclude that shrubs covered by snow affect the ground and the snowpack thermal regime even in alpine regions. The impact of this process on carbon cycling in mountains deserve further investigations.