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The relative influences of the responses of albedo and the exchange with the atmosphere of carbon dioxide in high latitude terrestrial ecosystems on the climate system

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When snow retreats, less solar energy is reflected to space and more solar energy is absorbed and transferred to the atmosphere. A reduction in snow cover duration and extent due to climate change results in a positive feedback loop that reinforces warming. The changes in energy associated with these dynamics may be comparable to those due to observed increases in atmospheric concentrations of carbon dioxide. However, the relative effects of these two sources of energetic shifts have received little attention. We compared these responses retrospectively based on simulations with a large-scale terrestrial ecosystem model for the land area north of 50º N, where surface air temperatures have generally increased and snow cover has generally decreased over the 1960-2000 time period. Decreases in snow cover duration from 1960 to 2000 were primarily due to earlier snow melt in the spring (0.09 - 0.26 days earlier year^{-1}), although later snow fall in the autumn was also detected (0.07 - 0.18 days later year^{-1}). The increase in snow free period was greatest in the boreal evergreen and boreal deciduous forests (0.4 – 0.5 days year^{-1}) and smallest (0.1 – 0.3 days year^{-1}) in the grasslands, wet tundra, and temperate forests. However, changes in energy due to decreases in snow cover were highest in grasslands (+4.6 W m^{-2})and tundra (+4.2 W m^{-2}), where seasonal differences between snow-covered and snow-free surfaces are greatest. In the boreal evergreen and boreal deciduous forests changes in energy were +2.0 to +3.8 W m^{-2}, while in the boreal deciduous conifers, this change in energy was slightly weaker (+1.3 W m^{-2}). Across the entire study domain, our findings suggest

that changes in energy due to changes in snow cover show a heating effect of +2.4 W m^{-2} while changes in energy due to increases in atmospheric CO_2 show a cooling effect of -0.10 W m^{-2}. These results indicate that the effects of a longer snow-free season on atmospheric energy balances should considered in studies of climate change, particularly with respect to associated shifts in vegetation between forests, grasslands, and tundra.