Basic physics predicts stronger high cloud radiative heating with warming

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Radiative heating of clouds, particularly those at high altitudes, alters temperature gradients in the atmosphere, affecting circulation and precipitation in today's and future climates. However, the response of cloud radiative heating to global warming remains largely unknown. We study changes to cloud radiative heating profiles in a warmer climate, identify physical mechanisms responsible for these changes, and develop a theory based on well-understood physics to predict them. Our approach involves a stepwise procedure that builds upon a simple hypothesis of near-isothermal cloud and cloud radiative heating vertical shift, gradually incorporating additional physical effects. We find that cloud radiative heating intensifies as clouds move to higher altitudes, despite minimal changes in cloud properties and temperatures. We attribute this intensification to a decrease in air density, which often overcompensates for the decrease in high cloud fraction with warming in idealized multi-model simulations in radiative-convective equilibrium. Furthermore, we find a vertical shift and an increase in tropical mean cloud radiative heating in a 15-year satellite-derived dataset. The density-mediated increase in cloud radiative heating may increase the role of high clouds in controlling atmospheric flows in a warmer climate.