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Rapid Warming in the Colorado Rocky Mountains, U.S.: The Alpine Critical Zone Under Transition

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Increasing evidence shows that air temperature is rising faster in high elevation mountain landscapes versus lowland regions. While globally, climate warming occurs at an average rate of 0.2 ± 0.1 °C / decade, high elevation regions are warming on average 0.3°C ± 0.3 °C / decade. Predicting how mountain landscapes will change in response to climate forcings is complicated by spatial variability of the alpine critical zone, including microtopographical gradients that lead to differences in soil properties (e.g., moisture, temperature, depth, and organic matter content), which in turn affect biogeochemical cycling, we well as the composition and abundance of plant communities and wildlife over short length scales. In this talk, I will share results of several recent studies at the Niwot Ridge Long-term Ecological Research (LTER) site in the Colorado Rocky Mountains, U.S., that provide insight into how climate-driven changes in the alpine critical zone are affecting the cycling of carbon (C), nitrogen (N), sulfur (S), and metals, as well as the timing and degree to which the landscape is hydrologically connected during the year. Recent data indicate that even as air quality regulation has decreased the inputs of oxidized N and S, unregulated atmospheric deposition of ammonium-N is on the rise, the melting of permafrost features is changing the timing and amounts of surface water flows, and losses of these and other ice features is increasing export of sulfate to surface water. Wetter portions of the landscape are now accumulating C, N, and S, and have become hotspots of methylmercury production—a neurotoxin that bioaccumulates and biomagnifies in the food web. Together, these studies provide an emergent picture of how mountain landscapes are changing under a warming climate and other anthropogenic pressures, the cascade of consequences for critical zone processes, and the issues that we must quickly confront to mitigate their loss.