Cleaner snow boosts future snowpack predictions

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Credit: AI-generated image (disclaimer)

Less pollution settling into snow should help cut the decline of snowpack in the Northern Hemisphere later this century. Though the snowpack will still diminish due to rising temperatures, the outlook is less dire when the cleaner snow of the future is considered.

In some scenarios, the researchers predict that the reduction in snowpack will be less than half what has been predicted—good news for the many people who rely on subsequent snowmelt in high mountains for water and food production, as well as for those who depend on winter recreation.

The findings come from scientists at the Department of Energy's Pacific Northwest National Laboratory who weighed several factors that affect snowpack. These include warming temperatures, pollution, dust and even the shape of snow grains as they pack together on the ground.

The findings were published October 2 in *Nature Communications*.

Clean snow vs. dirty snow

"Snow is not just snow," said Dalei Hao, first and corresponding author of the study. "There's clean snow and there's dirty snow, and how they respond to sunlight is very different. And then there are the shapes of the snow grains, which are anything but uniform. These all affect the snowpack."

Of course, the warmer it is, the more snow melts. That's why the coming decades spell bad news for mountain snowpacks and the people who rely on them. Researchers estimate that 2 billion people rely on spring and summer snowmelt in the mountains to provide fresh water for drinking and food production. If mountain snow melts faster or earlier than usual, that spells trouble—swollen rivers and flooding in the spring, then parched crops and wells in late summer.

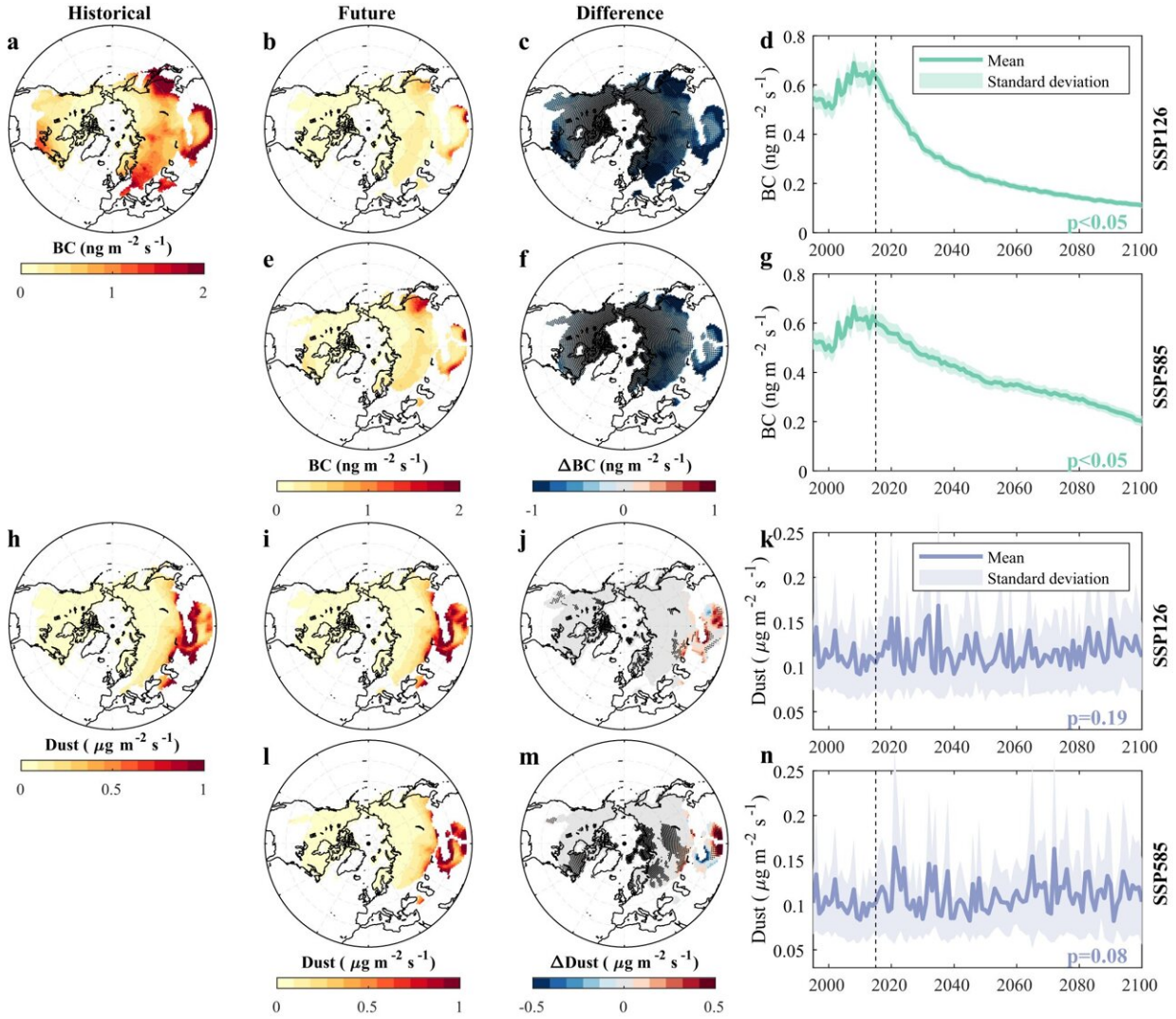
"There have been a lot of alarming projections about the future snowpack. It's a critically important issue," said PNNL scientist Ruby Leung, also a corresponding author of the study. "The Himalayas, for instance, are the headwaters for several major rivers in southeast and

eastern Asia. The condition of the snowpack in mountains has a direct effect on the quality of life for millions of people."

Of all the factors affecting future snowpack, the biggest in the study were temperature and the effect of dark particles like pollution and dust. Those particles absorb more sunlight than pure snow, warming faster and passing along the sun's warmth to nearby snow. That's why snow peppered with dark specks melts faster than clean snow.

These particles come from human activity, such as car and truck emissions or burning wood. Or they can come naturally from blowing dust—though how much dust blows and settles on snow is often a direct result of what people do.

While clean snow reflects an estimated 80 to 90% of sunlight, dirty snow reflects less—a huge variable that the PNNL team said has not been studied as thoroughly as the effect of temperature. Researchers believe that cleaner snow can be expected in the future, due to less pollution and less wood burning.



Historical and future deposition rate of black carbon (BC) and dust. a, h Historical (1995–2014) and b, e, i, l future (2081–2100) spatial patterns of aerosol deposition rates and c, f, j, m their differences (calculated as Future - Historical) for BC and dust under SSP126 and SSP585. d, g, k, n Time series of the average deposition rate of BC and dust for snow-covered regions over the Northern Hemisphere (NH) where the average snow water equivalent (SWE) from December to May exceeds 5 mm. Historical and future deposition rates are calculated based on the ensemble mean of seven CMIP6 model outputs from December to May. In a–c, e, f, h–j, i–m grids with an average SWE from December to May < 5 mm are masked. In c, f, j, m the black dots represent regions with statistically significant trends (p