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How soot killed the Little Ice Age

Industrial revolution kicked off Alpine glacier retreat fifty years before warming began.

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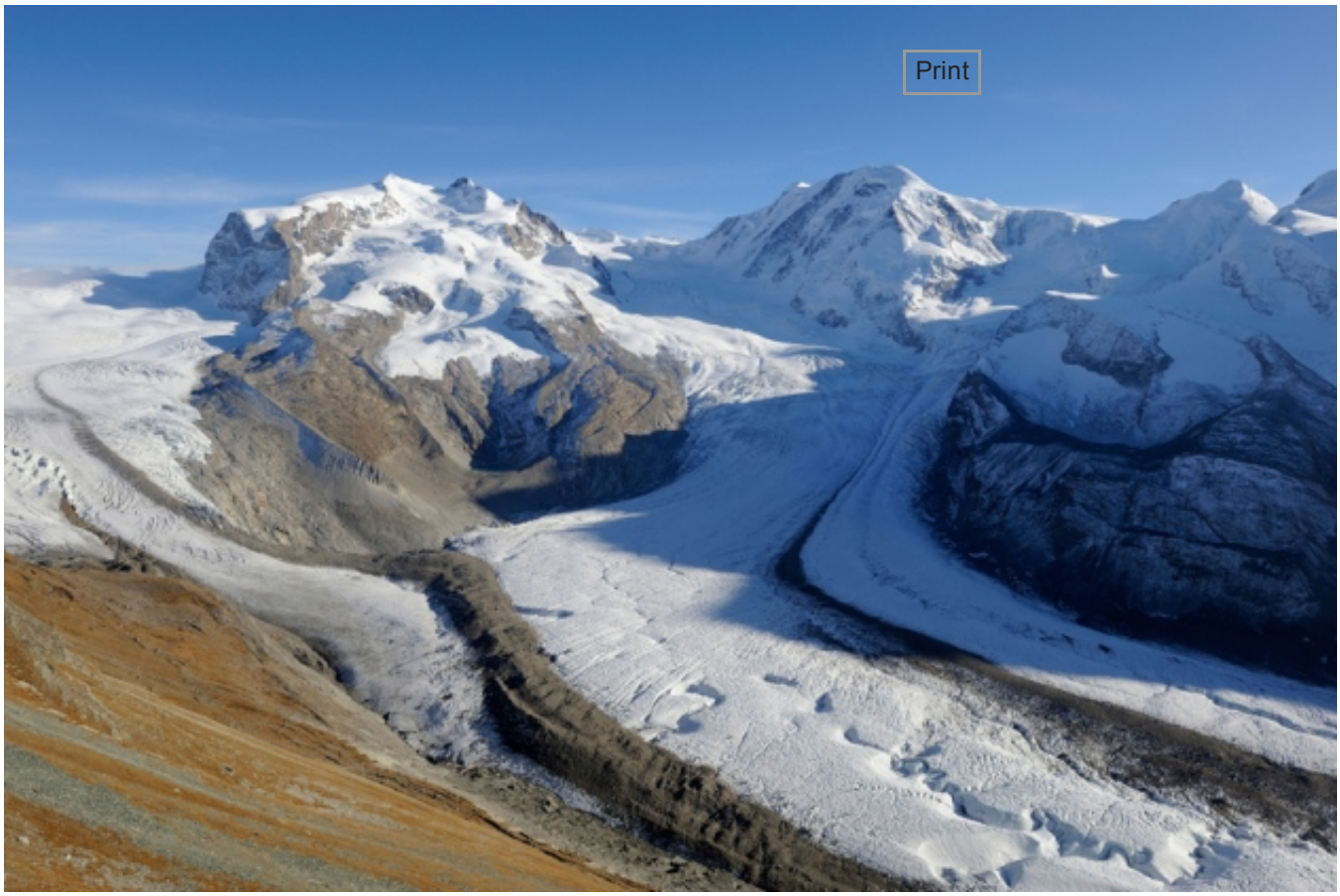

Soot deposits from glaciers on the Monte Rosa massif in the Swiss–Italian Alps have revealed why glaciers began to retreat in the mid-nineteenth century.

IMAGEBROKER/ALAMY

Rising air pollution in the wake of the Industrial Revolution seems to be the explanation for a long-standing enigma in glaciology. The emission of soot from Europe's proliferating factory smokestacks and steam locomotives explains why glaciers in the Alps began their retreat long before the climate warming caused by human activities kicked in, a study suggests.

The 4,000 or so large and small Alpine glaciers — which today are acutely threatened by rising air temperatures — did well throughout the relatively cool 500-year period known as the Little Ice Age, which began around the end of the thirteenth century. At its maximum in the middle of the nineteenth century, the

extent and volume of Alpine glaciers was at least twice what it is now.

But then these glaciers suddenly began to retreat. Other regions of the world may also have been affected — the decline was only well documented in the Alps — and, conventionally, climate scientists consider the Little Ice Age to have ended soon after 1850.

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However, despite the glaciers' shrinking, average global temperatures did not rise significantly until the end of the century. In fact, Alpine climate records — among the most abundant and reliable in the world — suggest that glaciers should have continued to grow for more than a half century, until around 1910.

“Something gnawed on the glaciers that climate records don’t capture,” says Georg Kaser, a glaciologist at the University of Innsbruck in Austria and a member of the team that built the case against black carbon, or soot, this week in *Proceedings of the National Academy of Sciences*[1]. “A strong decline in winter snowfall was often assumed to be the culprit,” he says. “But from all that we know, no such decline occurred.”

Retreat riddle

At a glacier-science workshop two years ago at the Pontifical Academy of Sciences at the Vatican, Kaser discussed the riddle with Thomas Painter, a snow hydrologist at NASA’s Jet Propulsion Laboratory in Pasadena, California, who had been researching the climate impact of atmospheric particles, known as aerosols. Might soot particles from the burning of organic fuels be the overlooked cause of the untimely melting of Alpine glaciers? The pair decided to investigate.

Because darker surfaces absorb more heat, if enough soot deposits onto snow and ice it can accelerate melting. Historical records suggest that by the mid-nineteenth century, the air in some Alpine valleys was thick with pollution. “Housewives in Innsbruck refrained from drying laundry outdoors,” says Kaser.

Scientists had thought it unlikely that sufficient soot had been carried high enough to affect glacier melting, but it seems they were mistaken. When Kaser's team looked at ice cores previously drilled at two high-elevation sites in the western Alps — the Colle Gnifetti glacier saddle (elevation 4,455 metres) on Monte Rosa near the Swiss–Italian border and the Fiescherhorn Glacier (3,900 metres) in the Bernese Alps — they found that at around 1860, layers of glacial ice started to contain surprisingly large amounts of soot.

The team converted the energetic effect that this soot that would have had on glaciers at the time into equivalent changes in air temperature. When included in a simplified mass-balance model, the melting effect of black carbon nicely explained the observed Alpine glacier retreat without the need for unrealistic

increases in precipitation to be made to the model.

“The modelling could be further refined,” says Andreas Vieli, a glaciologist at the University of Zurich in Switzerland who was not involved in the study. “But even so, this study offers a very elegant and plausible explanation for the glacier conundrum. It appears that in central Europe soot prematurely stopped the Little Ice Age.”

Only after around 1970, when air quality began to improve, did accelerated climate warming become the dominant driver of glacier retreat in the Alps, Kaser says. If glaciers in the region continue to melt at the rate observed during the past 30 years, there is a risk that nearly all of them will vanish before the end of the century, he adds.

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References

1. Painter, T. H. *et al. Proc. Natl Acad. Sci. USA* http://dx.doi.org/10.1073/pnas.1302570110 (2013).
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Interestingly, volcanic eruptions may have contributed to the magnitude of the Little Ice Age, or extended it. See http://en.wikipedia.org/wiki/Volcano#Effects_of_volcanoes "The 1815 eruption of Mount Tambora created global climate anomalies that became known as the "Year Without a Summer" because of the effect on North American and European weather.[18] Agricultural crops failed and livestock died in much of the Northern Hemisphere, resulting in one of the worst famines of the 19th century.[19] The freezing winter of 1740–41, which led to widespread famine in northern Europe, may also owe its origins to a volcanic eruption.[20]"

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