Better understanding the reasons behind Arctic amplified warming

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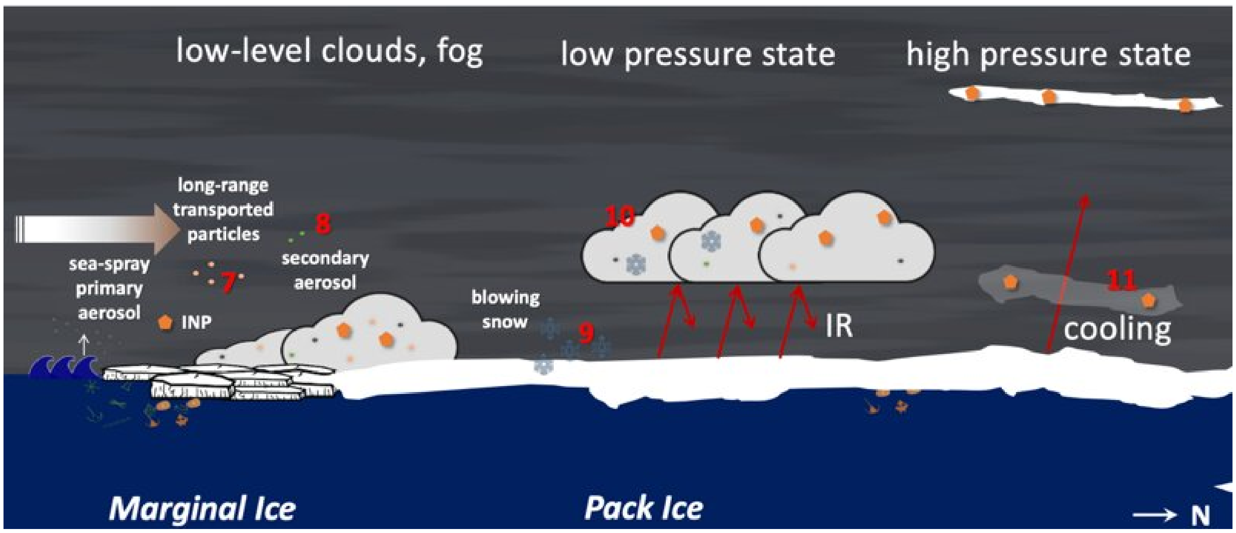

Schematic showing aerosol processes of climate relevance in the Arctic for polar night. Abbreviations stand for: INP - ice nucleating particles, IR - infrared. Red arrows indicate longwave radiation. Credit: © EERL

It's clear that rising greenhouse gas emissions are the main driver of global warming. But on a regional level, several other factors are at play. That's especially true in the Arctic—a massive oceanic region around the North Pole which is warming two to three times faster than the rest of the planet. One consequence of the melting of the Arctic ice cap is a reduction in albedo, which is the capacity of surfaces to reflect a certain amount of solar radiation. Earth's bright surfaces like glaciers, snow and clouds have a high reflectivity. As snow and ice decrease, albedo decreases and more radiation is absorbed by the Earth, leading to a rise in near-surface temperature.

The other regional, yet much more complex factor that scientists need to pay detailed attention to relates to how clouds and aerosols interact. Aerosols are tiny particles suspended in the air; they come in a wide range of sizes and compositions and can occur naturally—such as from sea spray, marine microbial emissions or forest fires (like in Siberia)—or be produced by human activity, for example from the combustion of fossil fuels or agriculture. Without aerosols, clouds cannot form because they serve as the surface on which water molecules form droplets. Owing to this role, and more specifically to how they affect the amount of solar radiation that reaches the Earth surface, and the terrestrial radiation that leaves the Earth, aerosols are an essential element in regulating the climate and Arctic climate in particular.

"A lot of question marks"

In a paper published in *Nature Climate Change* on 8 February, Julia Schmale, the head of EPFL's Extreme Environments Research Laboratory, alerts the scientific community to the need for a better understanding of aerosol-related processes. "How albedo is affected by ice is fairly well understood—there are established maximum and minimum values, for example," says Schmale. "But when it comes to groups of aerosols, there are many variables to consider: will they reflect or absorb light, will they form a cloud, are they natural or anthropogenic, will they stay local or travel long distances, and so on. There are a lot of question marks out there, and we need to find the answers." She worked on the paper with two coauthors: Paul Zieger and Annica M. L. Ekman, both from the Bolin Centre for Climate Research at Stockholm University.

Schmale has carried out several research expeditions to the North Pole, most recently in early 2020 on the German icebreaker Polarstern. She saw first-hand that the Arctic climate tends to change fastest in the winter—despite there being no albedo during this period of 24-hour darkness. Scientists still don't know why. One reason could be that clouds present in winter are reflecting the Earth's heat back down to the ground; this occurs to varying degrees depending on natural cycles and the amount of aerosol in the air. That would lift temperatures above the Arctic ice mass, but the process is extremely complicated due to the wide range of aerosol types and differences in their capacity to reflect and absorb light. "Few observations have been made on this phenomenon because, in order to conduct research in the Arctic in the wintertime, you have to block off an icebreaker, scientists and research equipment for the entire season," says Schmale.

Improving weather models

Although many research expeditions have already been carried out in the Arctic, a lot remains to be explored. One option could be to collect all the discoveries made so far on Arctic warming and use them to improve existing weather models. "A major effort is needed right away, otherwise we'll always be one step behind in understanding what's going on. The observations we've already made could be used to improve our models. A wealth of information is available, but it hasn't been sorted through in the right way to establish links between the different processes. For instance, our models currently can't tell us what kinds of aerosols contribute the most to climate change, whether local or anthropogenic," says Schmale.

In their paper, the research team puts forth three steps that could be taken to gain better insight into the Arctic climate and the role played by aerosols. They suggest creating an interactive, open-source, virtual platform that compiles all Arctic knowledge to date. They point to the

International Arctic Systems for Observing the Atmosphere (IASOA) program as an example; the IASOA coordinates the activities of individual Arctic observatories to provide a collaborative international network for Arctic atmospheric research and operations. "We need to improve our climate models because what's happening in the Arctic will eventually spread elsewhere. It's already affecting the climate in other parts of the northern hemisphere, as we've seen with the melting glaciers and rising sea levels in Greenland. And to develop better models, a better understanding of aerosols' role will be crucial. They have a major impact on the climate and on human health," says Schmale.

Provided by Ecole Polytechnique Federale de Lausanne

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