How do boreal wildfire smoke aerosols change Arctic ice clouds?

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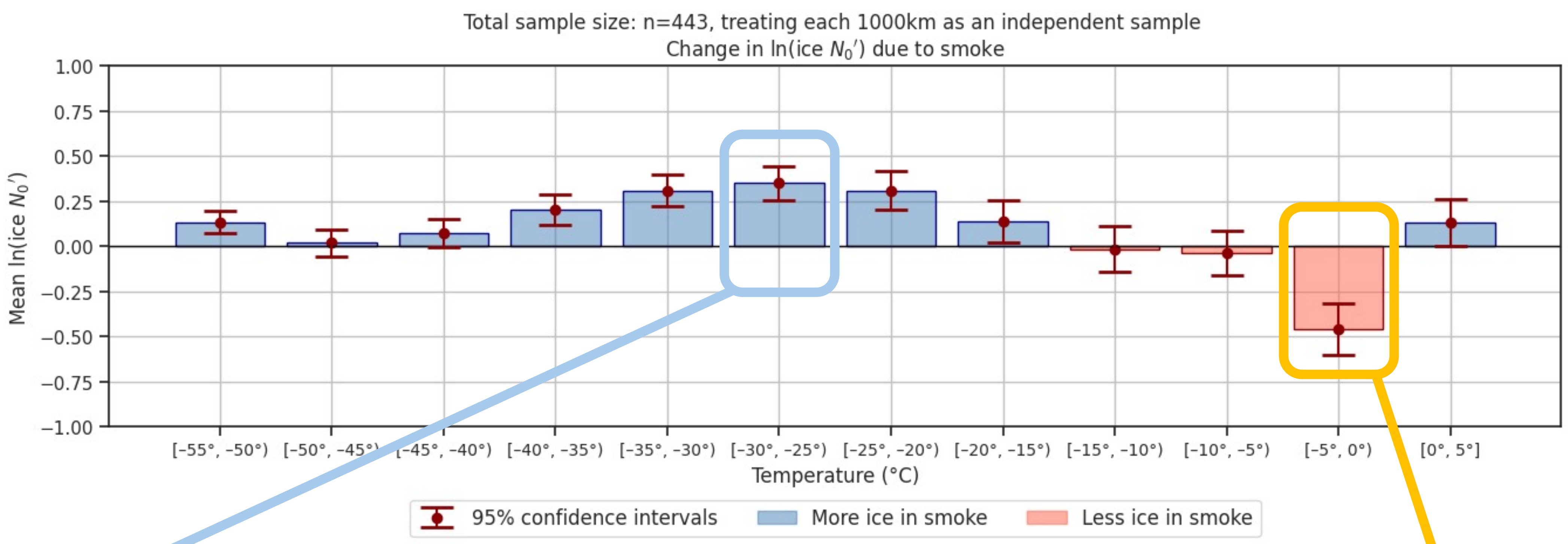
Wildfires in boreal regions are increasing in frequency and severity, and the microphysical effects of wildfire smoke on ice clouds are still highly uncertain. Some studies have found that wildfire smoke aerosols function as ice-nucleating particles, especially at relatively warmer temperatures.[a,b] **Our results align with these findings, showing higher ice crystal number concentrations with smaller effective radii in smoky vs clear cases at colder temperatures, and lower ice crystal number concentrations with larger effective radii at warmer temperatures.**

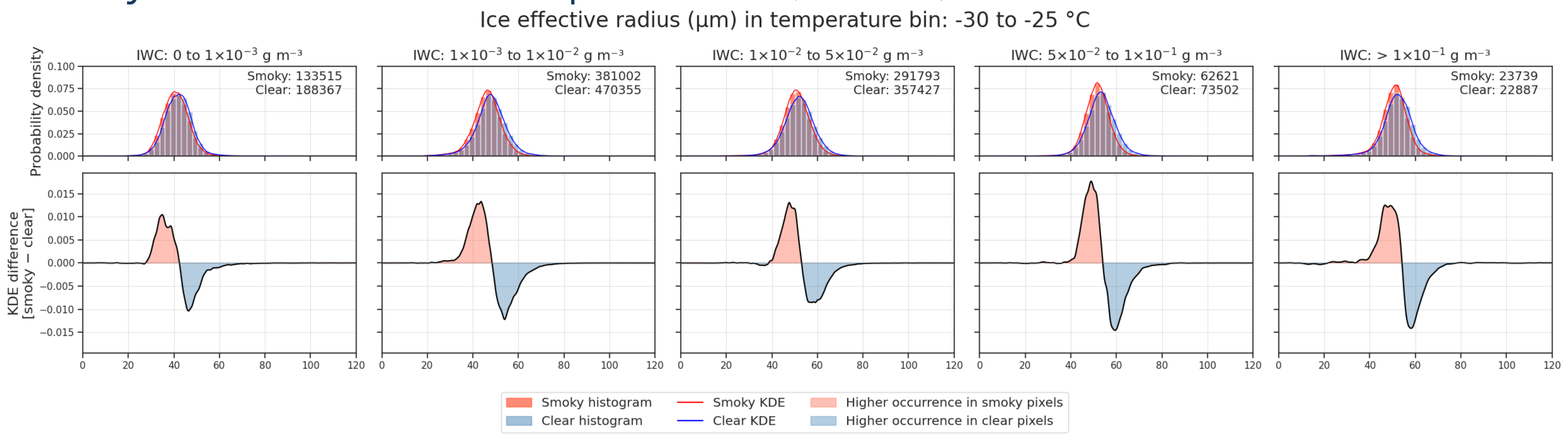
[a] Impact of wildfire smoke on Arctic cirrus formation – Part 1: Analysis of MOSAiC 2019–2020 observations, Ansmann et al. 2025
[b] Impact of Canadian wildfires on aerosol and ice clouds in the early-autumn Arctic, Sato et al., 2025

Comparing the smoky and clear populations with ice N_0' from ACM-CAP

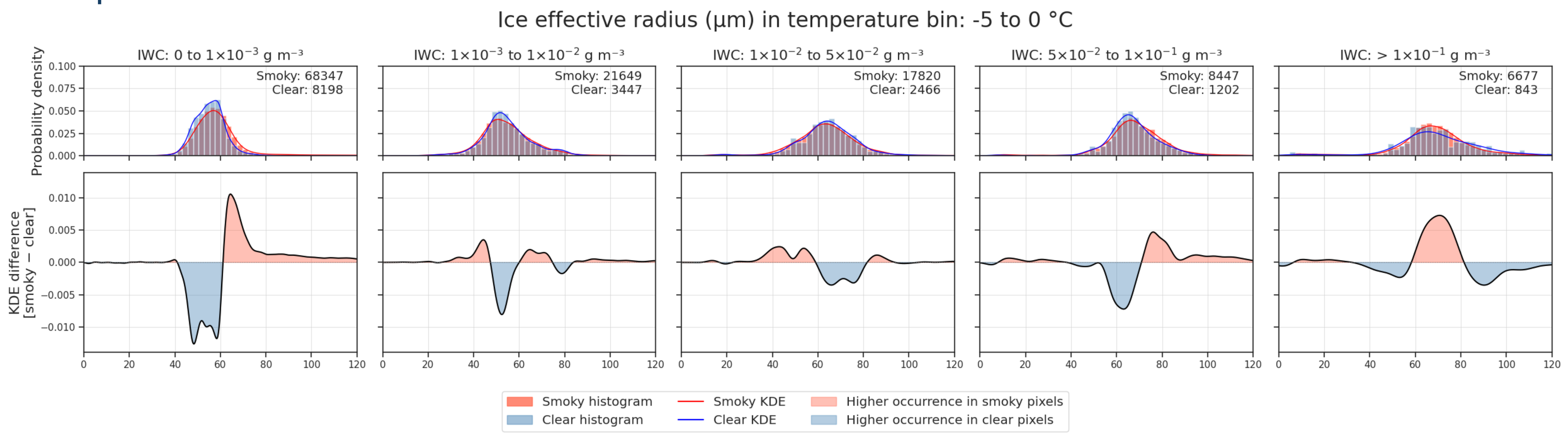
Ice $N_0' = \text{ice } N_0^*/\alpha_v^{0.6}$, where ice N_0^* is the ice normalised number concentration and α_v is the visual extinction coefficient. Ice N_0' has a strong dependence on temperature but not on ice water content or extinction, so it makes a good prior estimate for retrievals. Here we limit our analysis to cases where both radar and lidar detect a cloud so that N_0' is not constrained by the prior.



Ice crystal effective radii are **more numerous and smaller** (≈–1.5μm) in smoky cases at lower temperatures (<15°C)



Ice crystals are **fewer and larger** (≈+2.5μm) in smoky cases at higher temperatures (>15°C)



Selecting smoky and clear samples

Our sample population is **443 C frames (>67.5°N)** from **May–June 2025**, a range that covers both clear periods and weeks when smoke from Canadian wildfires filled the polar upper stratosphere. Across this population, we have analysed approximately **2,215,000 km** of data. We filtered to ice-only pixels for better microphysical retrievals and to those detected by both radar and lidar to show departure from the N_0' prior.

Sometimes you can eyeball it (but how do you standardise it?)

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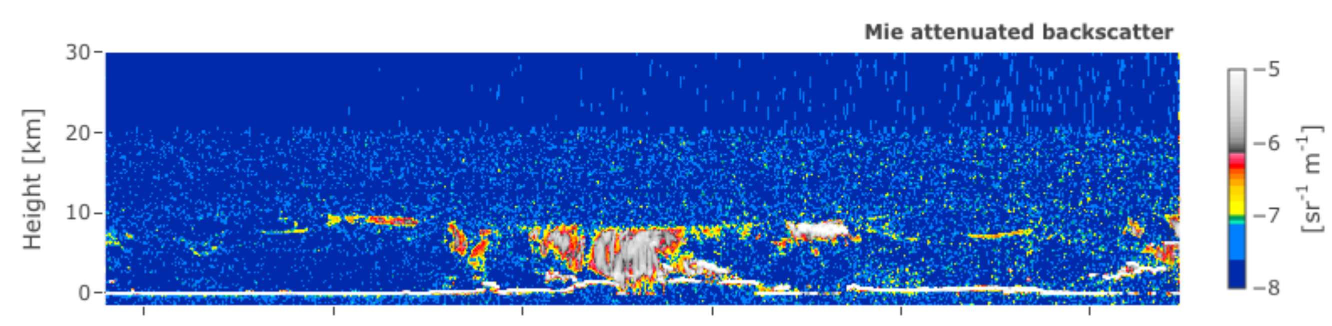

Relatively little background aerosol in May

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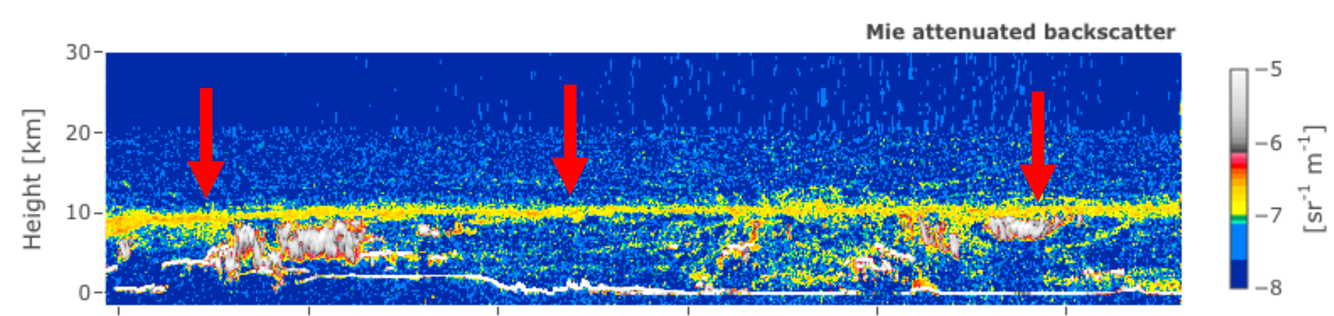
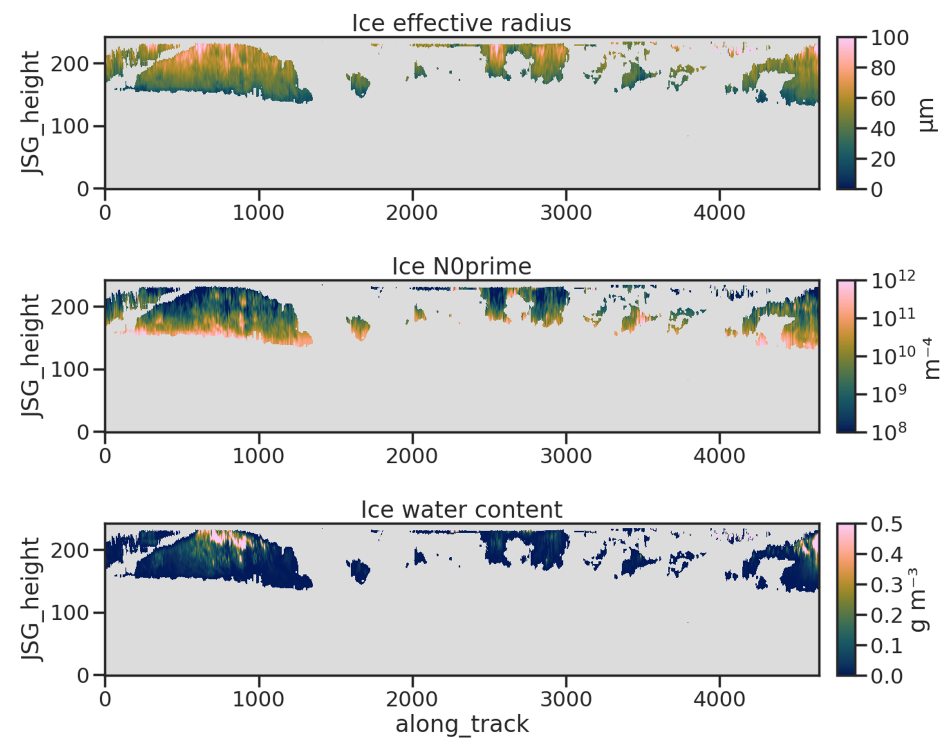


Thick blanket of wildfire smoke in June

Variables of interest



What's next?

How can we **automate and/or quantify** classification into smoky vs clear cases?

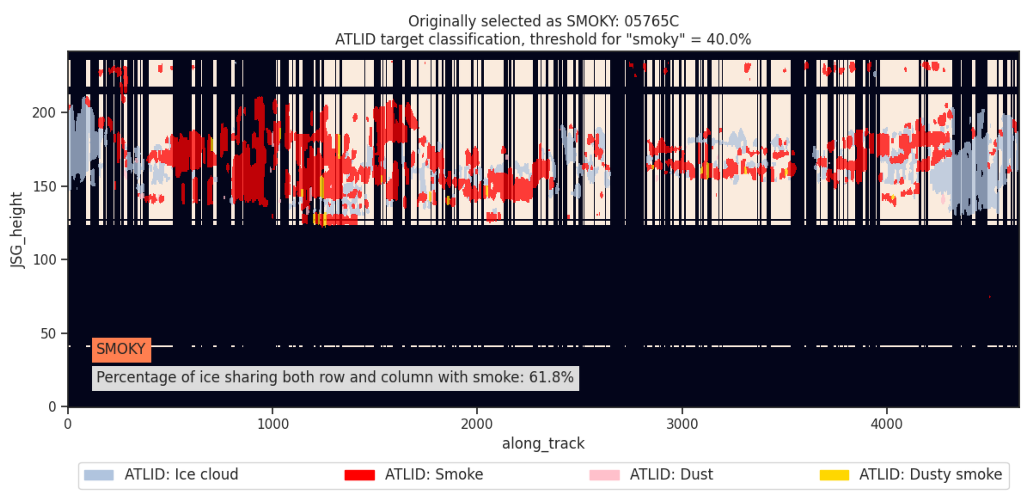
What's with **that range where ice decreases**? Are we seeing the optimal range for **biogenic ice-nucleating particles**?

How relevant is the as-yet-unexamined **liquid phase**?

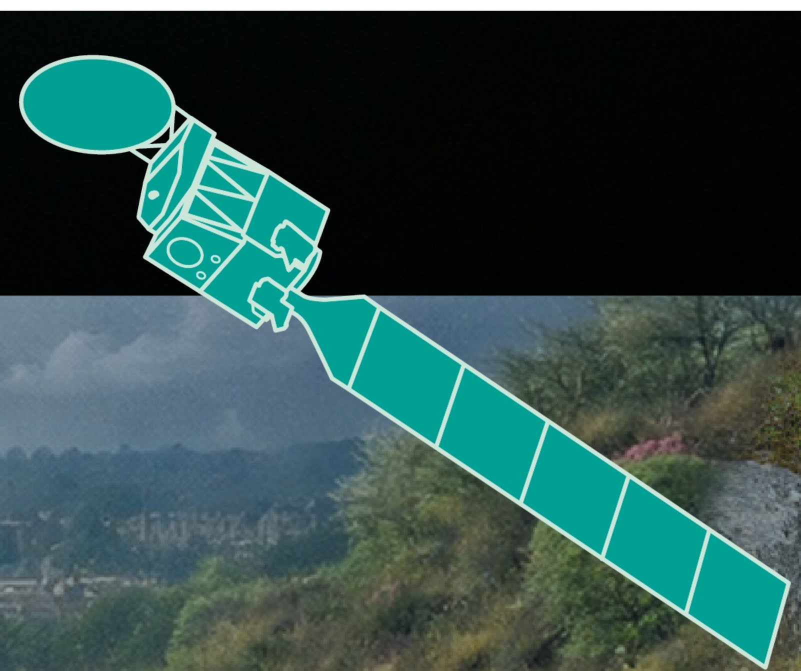
What might we see in **other ice variables**? Fallspeeds?

What's the **radiative effect** of these changes in cloud ice?

One idea for a feature-mask filter



How would you approach these questions? Talk to me about it.



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