SASIP: The Scale-Aware Sea Ice Project

Modeling the contribution of leads to sea spray aerosol in the high Arctic

Rémy Lapere, Louis Marelle, Pierre Rampal, Laurent Brodeau,
Christian Melsheimer, Gunnar Spreen, and **Jennie L. Thomas**

Workshop "Interfaces dans le système climatique"

CRiceS has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003826

CERTAINTY has received funding from Horizon Europe programme under Grant Agreement No 101137680

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CLOUD–AEROSOL INTERACTIONS & THEIR IMPACTS IN THE EARTH SYSTEM

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Team members in France

IGE
Institut des géosciences de l'environnement

LATMOS

Rémy Lapere

Pierre Rampal

Laurent Brodeau

Louis Marelle

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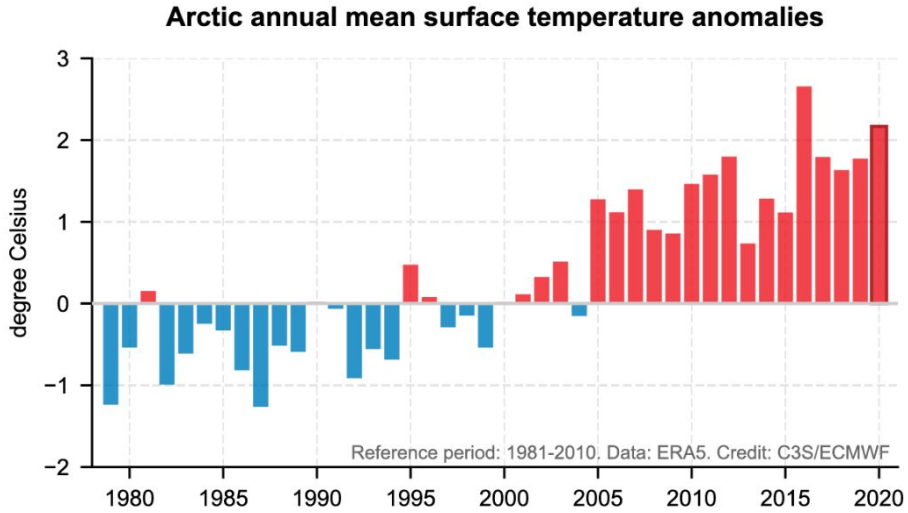
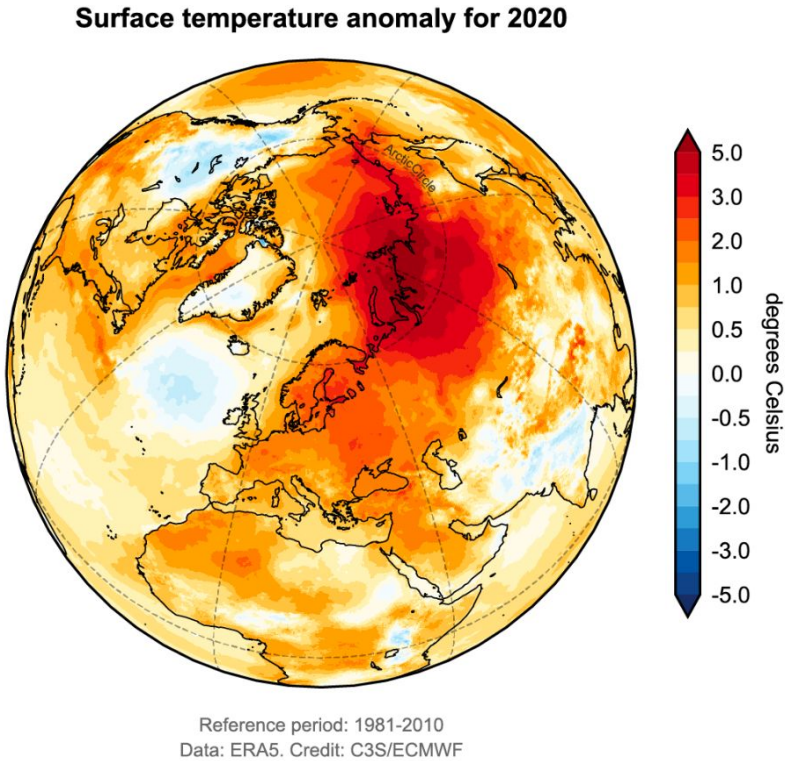
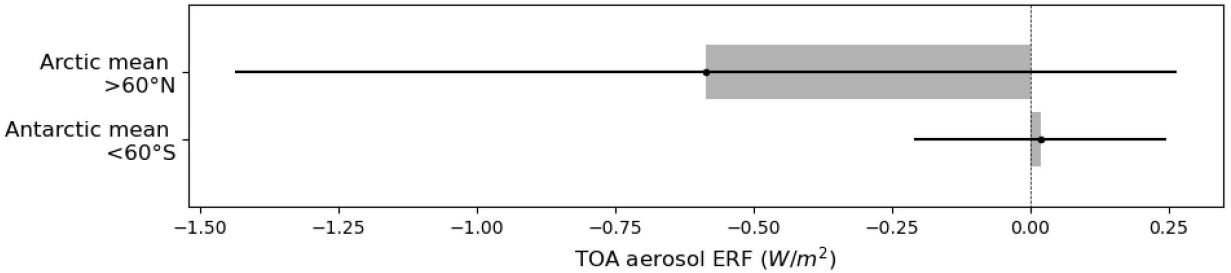




Temperature anomalies across the Arctic region (66.6° N–90°N) from ERA5, credit: C3S/ECMWF

Polar anthro. aerosol-cloud effective radiative forcing, CMIP6 ±2σ model spread



L. Marelle, LATMOS

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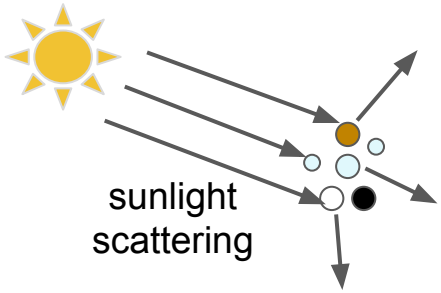
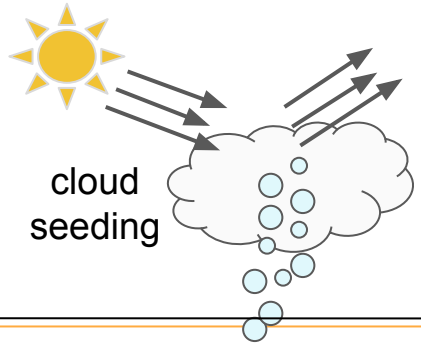


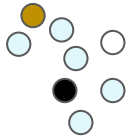


Long-range transport of aerosols

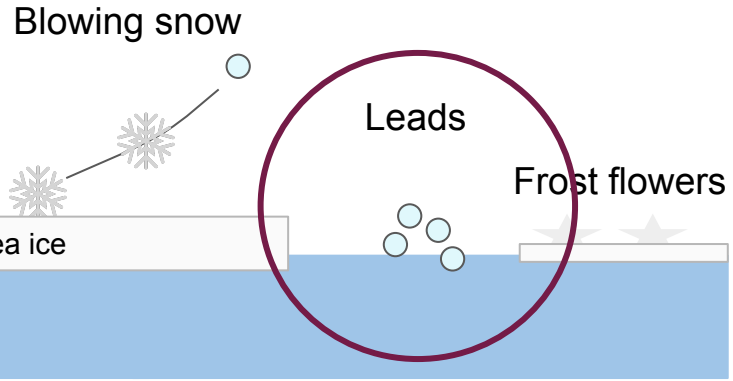
Local sources of sea salt

Dust
Black carbon
Sea salt
…

Wind



Northern Europe, North America, Russia…



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Perspective | Published: 08 February 2021

Aerosols in current and future Arctic climate

Julia Schmale, Paul Zieger & Annica M. L. Ekman

Nature Climate Change **11**, 95–105 (2021) | Cite this article

8938 Accesses | **118** Citations | **106** Altmetric | Metrics

Abstract

Mechanisms of Arctic amplification and Arctic climate change are difficult to pinpoint, and current climate models do not represent the complex local processes and feedbacks at play, in particular for aerosol–climate interactions. This Perspective highlights the role of aerosols in contemporary Arctic climate change and stresses that the Arctic natural aerosol baseline is changing fast and its regional characteristics are very diverse. We argue that to improve understanding of present day and future Arctic, more detailed knowledge is needed on natural Arctic aerosol emissions, their evolution and transport, and the effects on cloud microphysics. In particular, observation and modelling work should focus on the sensitivity of aerosol–climate interactions to the rapidly evolving base state of the Arctic.

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Article

Articles / Volume 23, issue 7 / ACP, 23, 4115–4122, 2023

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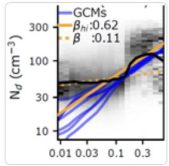
https://doi.org/10.5194/acp-23-4115-2023

ACP Letters | Highlight paper | 05 Apr 2023

Uncertainty in aerosol–cloud radiative forcing is driven by clean conditions



Edward Gryspeerdt, Adam C. Povey, Roy G. Grainger, Otto Hasekamp, N. Christina Hsu, Jane P. Mulcahy, Andrew M. Sayer, and Armin Sorooshian

Abstract

Atmospheric aerosols and their impact on cloud properties remain the largest uncertainty in the human forcing of the climate system. By increasing the concentration of cloud droplets (N_d), aerosols reduce droplet size and increase the reflectivity of clouds (a negative radiative forcing). Central to this climate impact is the susceptibility of cloud droplet number to aerosol (β), the diversity of which explains much of the variation in the radiative forcing from aerosol–cloud interactions (RFaci) in global climate models.

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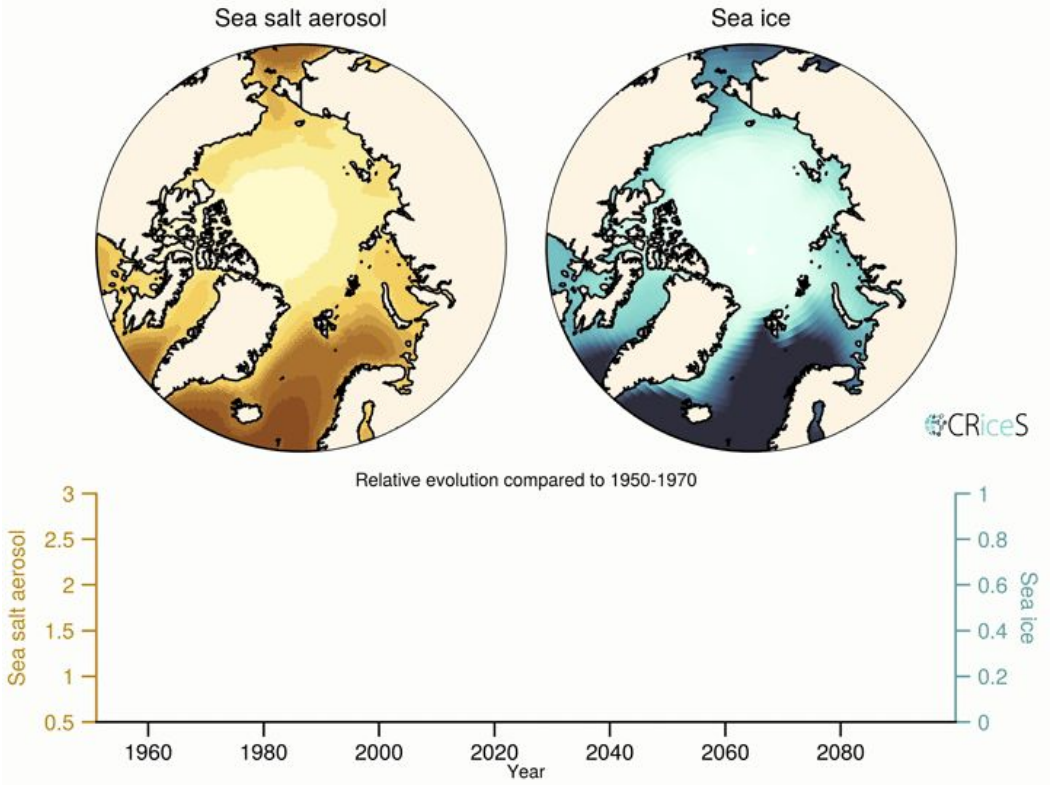
Polar sea-salt aerosol in climate models

Lapere, et al., 2023, *The Representation of Sea Salt Aerosols and Their Role in Polar Climate Within CMIP6*



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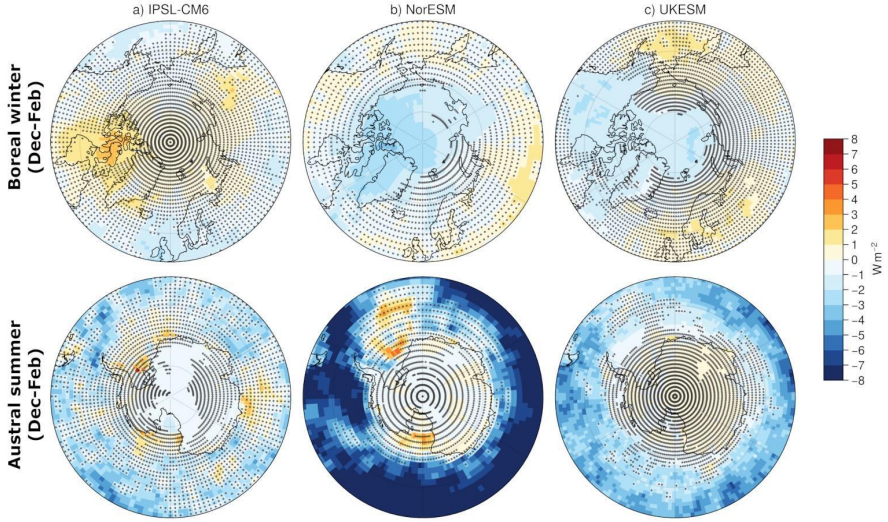
Change in SW+LW radiation with doubled sea salt emissions



2x sea salt => up to -10W/m2

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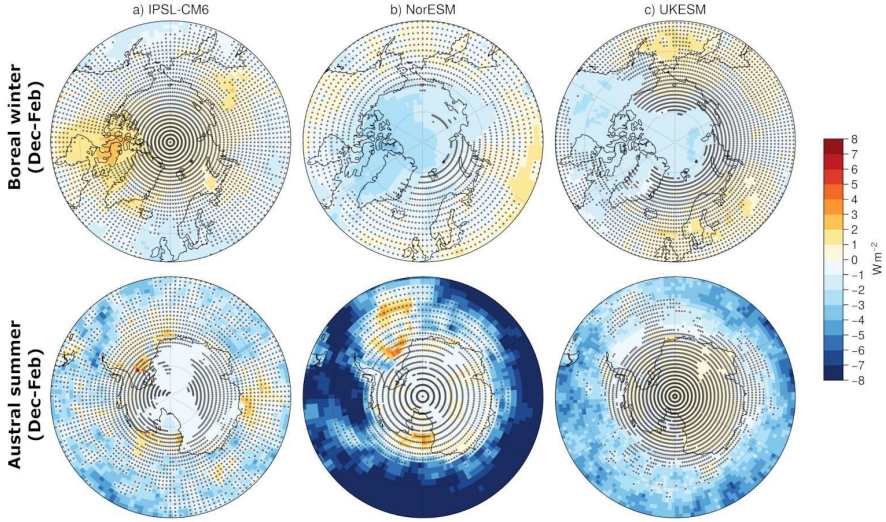

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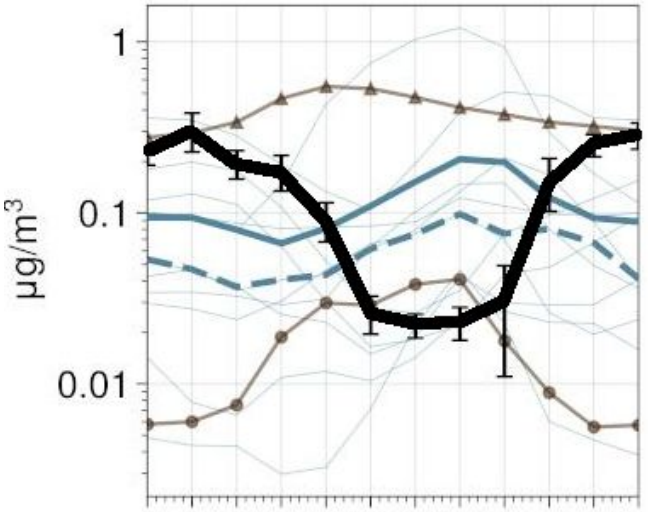
Arctic Na+ aerosols at Alert, Canada

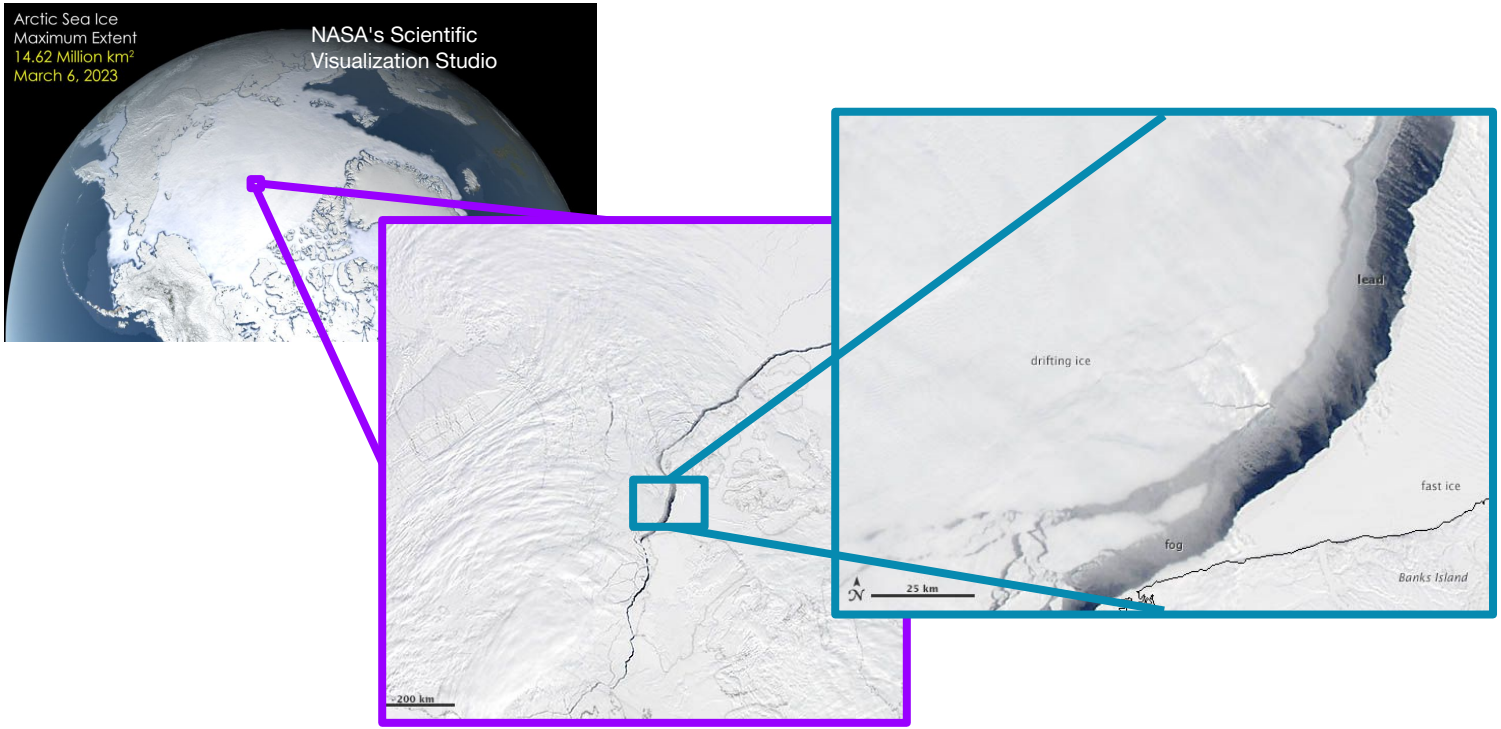


Na+ aerosol observations

CMIP6 model ensemble mean & median

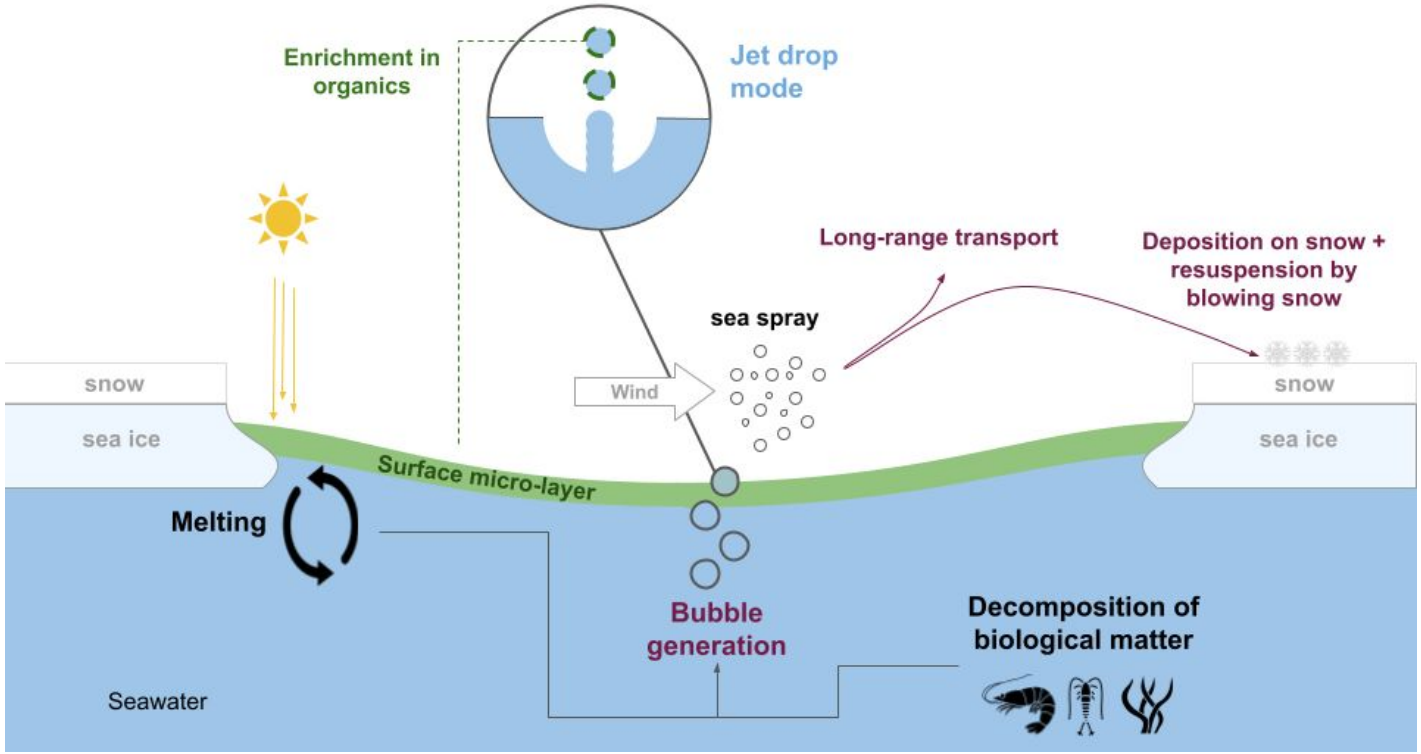
Relevance to GDR: Relations entre observations, données et intégration dans les modèles

What are leads?



https://climate.nasa.gov/news/923/ice-in-motion/

Lead emissions



Leads - proposed aerosol emissions parameterization

Lapere, et al., 2024, in review, *Modeling the contribution of leads to sea spray aerosol in the high Arctic*

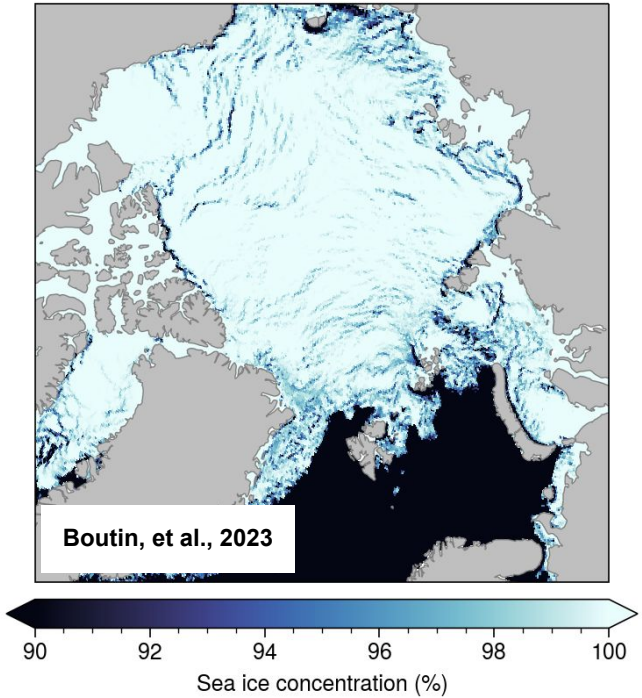
How much is emitted?

Nilsson et al., 2001	Open sea	Leads
Measured aerosol flux	*log(F)=0.20Ū-1.71*	***log(F)=0.11Ū-1.93***

Ratio open ocean/leads to be used in our parameterization

$$R_{\mathrm{Nilsson}} = \frac{F_{\mathrm{leads}}}{F_{\mathrm{oo}}} = \frac{\exp(0.11\bar{U} - 1.93)}{\exp(0.20\bar{U} - 1.71)}$$

Sea ice concentration from NEMO-neXtSIM



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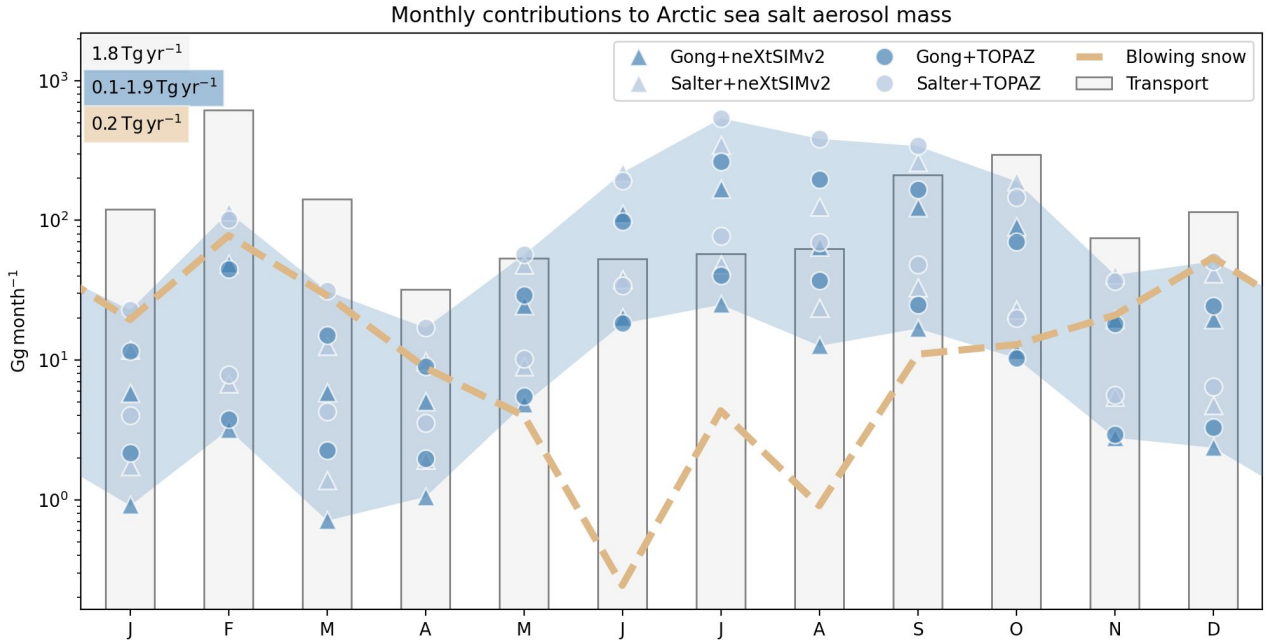

sea salt from leads could matter as much as transported open ocean sea salt

Leads - proposed aerosol emissions parameterization

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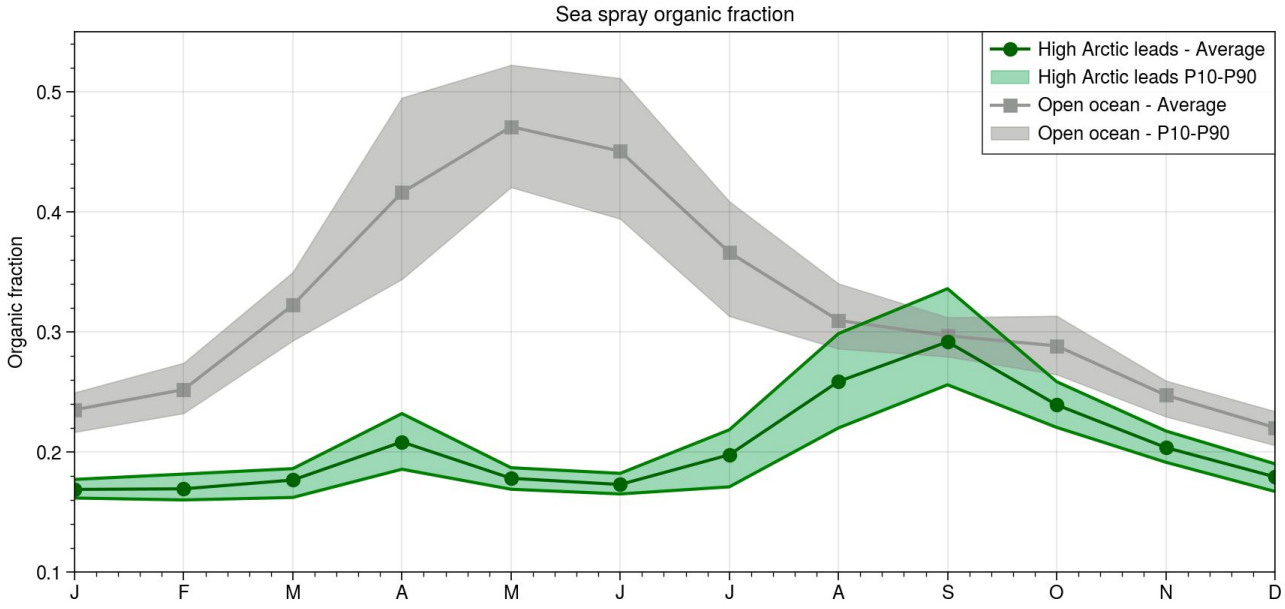
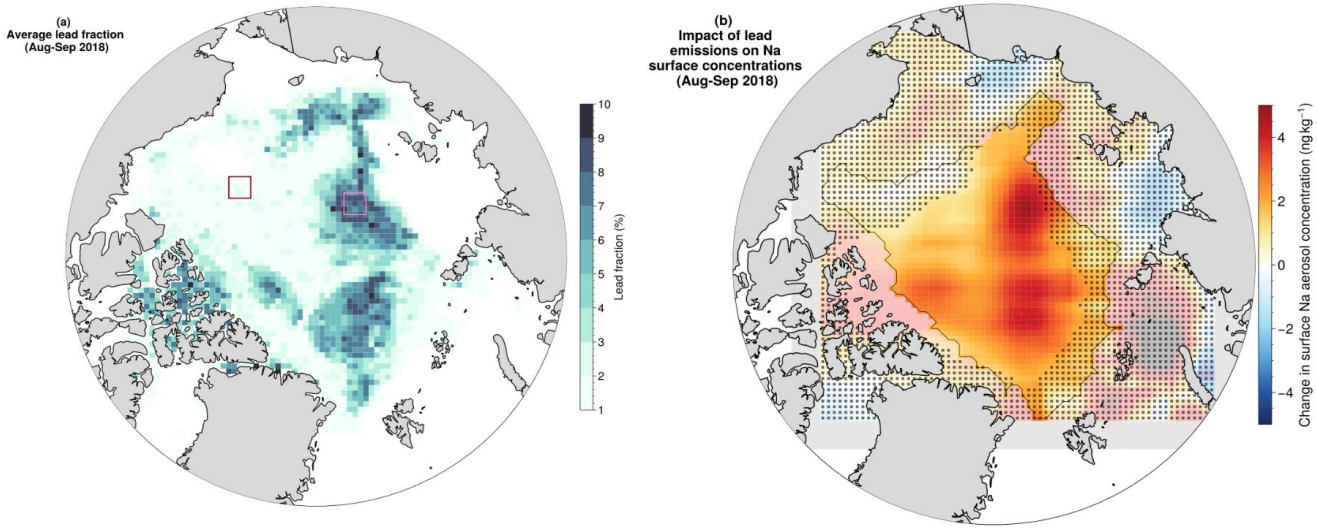


Important fraction of organics in sea spray from leads -> key for ice cloud formation
+ seasonality difference leads vs open ocean

Leads - proposed aerosol emissions parameterization

Lapere, et al., 2024, in review, *Modeling the contribution of leads to sea spray aerosol in the high Arctic*

Implementation in WRF-Chem



~12% of sea salt surface mass concentration comes from leads in summer

Conclusions / perspectives

Rémy Lapere

➔ Conclusions

- Developed a new emissions parameterization for sea spray emissions from leads
- Suggest organic and inorganic aerosol fraction, as that is a function of open ocean sea spray emissions
- Tested the parameterization in a regional model WRF-Chem and suggest that ~12 % of sea salt mass is from leads in summer

Lapere, et al., 2024, in review, *Modeling the contribution of leads to sea spray aerosol in the high Arctic*

➔ Perspectives

- Needs to be tested within a climate / Earth system modeling framework
- The role of increasing / changing sea spray aerosol emissions from leads under future sea ice conditions needs to be investigated
- The role of sea salt and lead emissions in controlling polar clouds (abundance, phase) needs further investigation