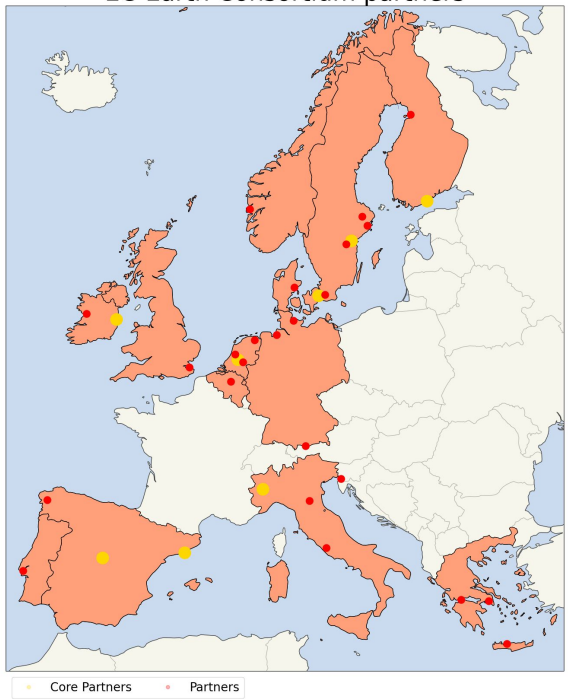
Overview of EC-Earth activities within the PEEX modeling platform

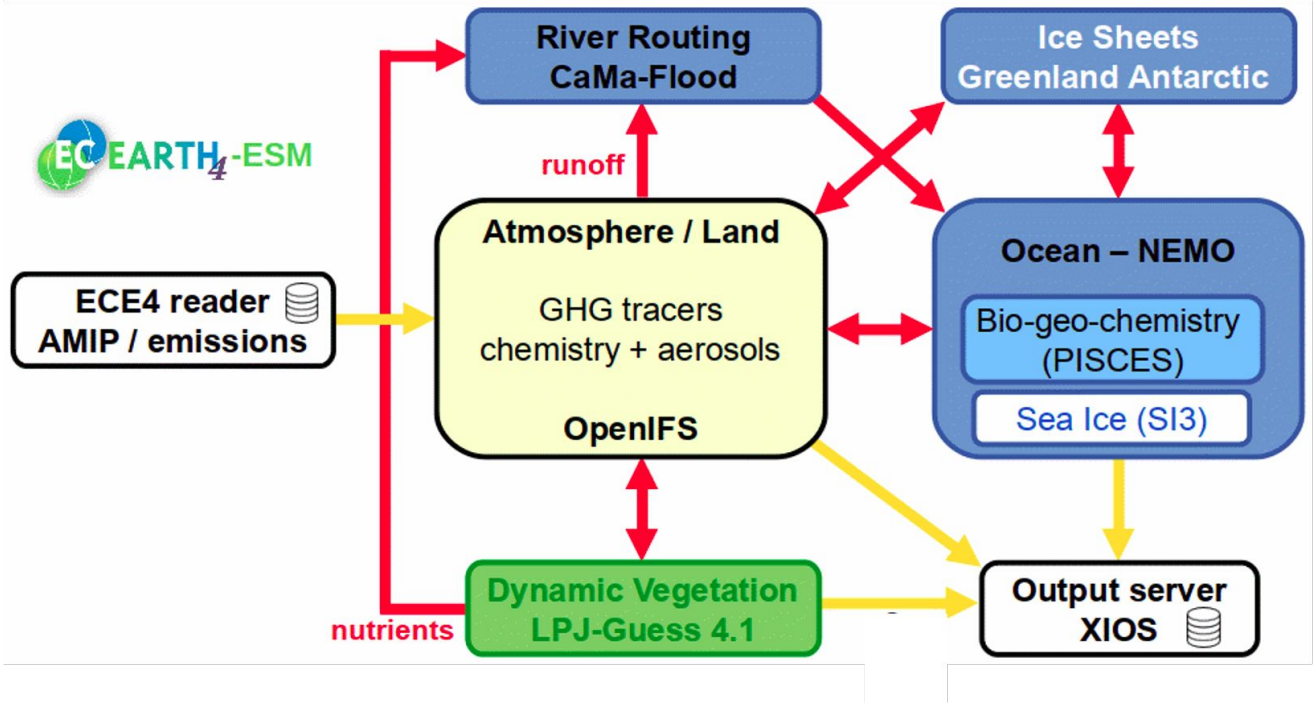
Risto Makkonen
Research Professor
Finnish Meteorological Institute

PEEX Online seminar 9.4.2026

EC-Earth Consortium partners



https://ec-earth.org/



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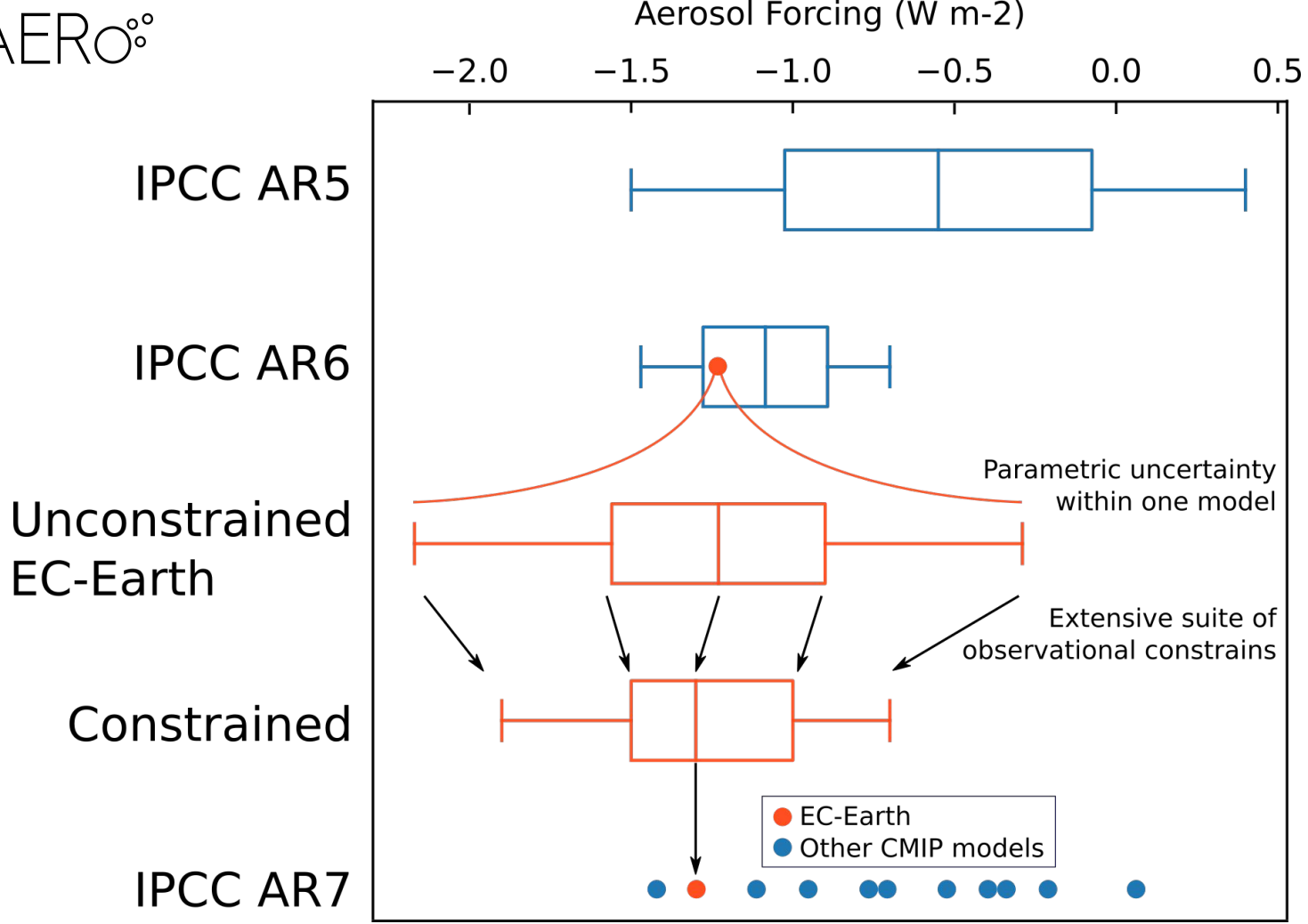
EC-Earth and **OpenIFS** provide excellent model platforms for PEEX collaboration!

ACCAERO



Constraining **A**erosol **R**adiative forcing with airborne **O**bservations (CARO) [Williamson, Makkonen]

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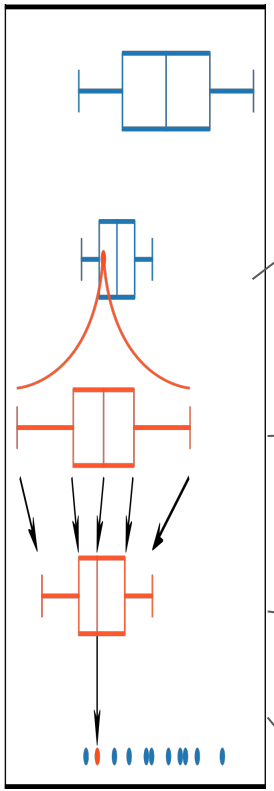
IPCC AR5

IPCC AR6

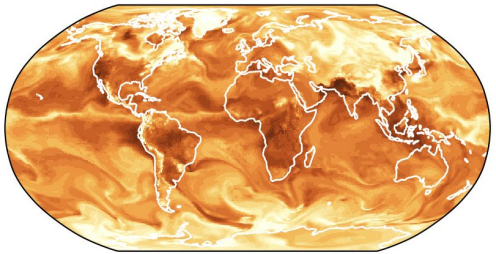
Unconstrained EC-Earth

Constrained

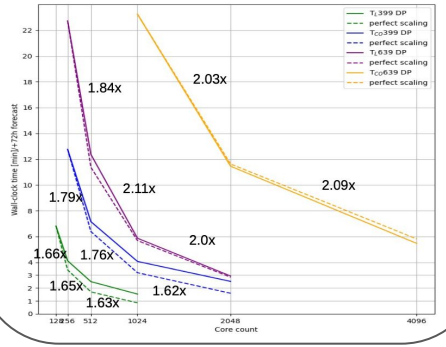
IPCC AR7



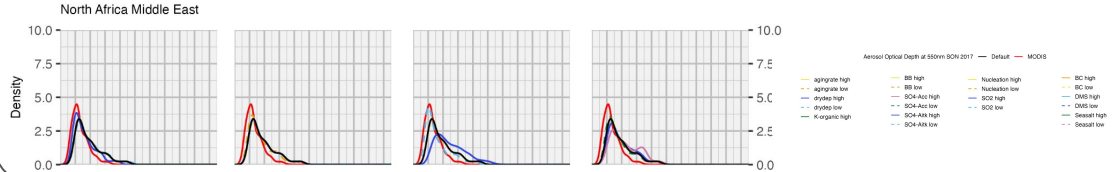
Developing EC-Earth aerosol model



Port & optimize EC-Earth in LUMI



Global observations to constrain simulations



Refactoring EC-Earth data-processing tools to NVIDIA and AMD GPUs

Constraining **A**erosol **R**adiative forcing with airborne **O**bservations (CARO) [Williamson, Makkonen]

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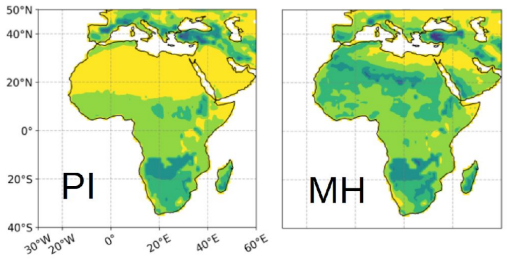
Simulating dust emissions and secondary organic aerosol formation over northern Africa during the mid-Holocene Green Sahara period

Zhou, P., Lu, Z., Keskinen, J.-P., Zhang, Q., Lento, J., Bian, J., van Noije, T., Le Sager, P., Kerminen, V.-M., Kulmala, M., Boy, M., and Makkonen, R.: Simulating the dust emissions and secondary organic aerosol formation over northern Africa during the mid-Holocene Green Sahara period, Climate of the Past, 19, 2445–2462, https://doi.org/10.5194/cp-19-2445-2023, 2023.

BVOC: biogenic volatile organic compounds (e.g., monoterpenes)



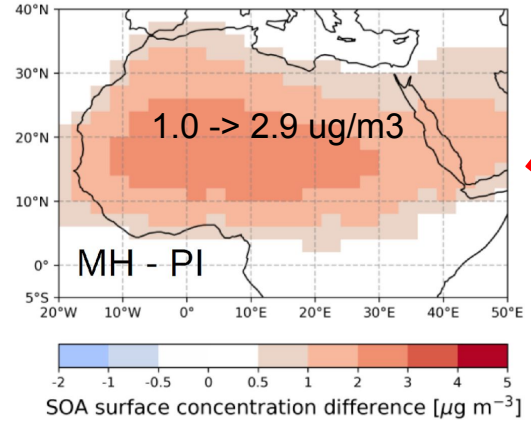
More BVOC emissions

Green Sahara

More vegetation growing over Northern Africa during mid-Holocene period (~ 6000 years ago; **MH**) compared to pre-industrial period (**PI**).

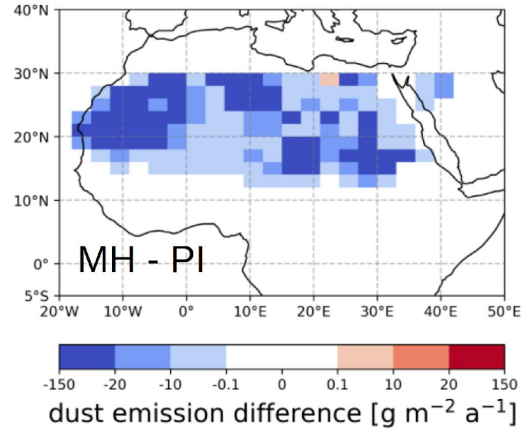
More SOA formation

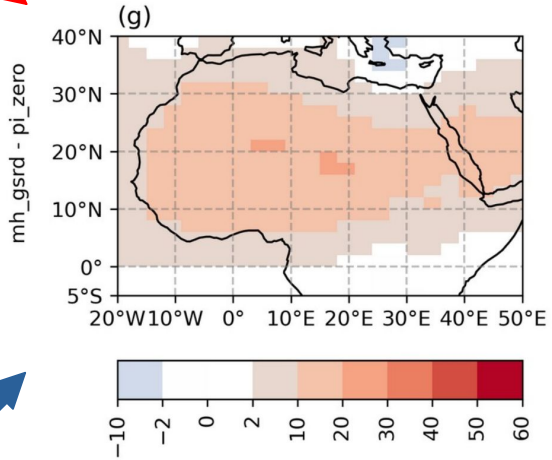
SOA: secondary organic aerosol



280.6 -> 26.8 Tg/a

Less dust emissions





CCN at 0.2% difference

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Article | Open access | Published: 14 July 2025

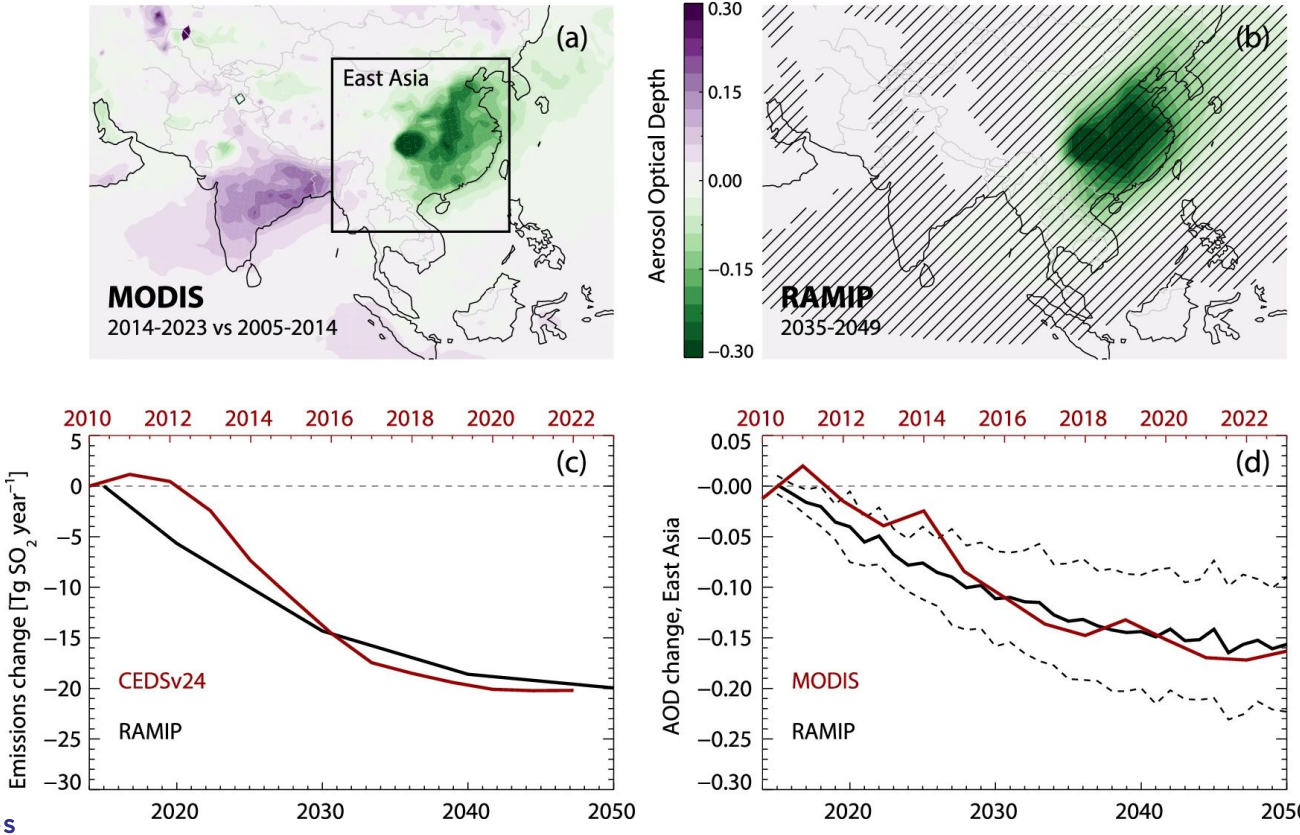
East Asian aerosol cleanup has likely contributed to the recent acceleration in global warming

Bjørn H. Samset, Laura J. Wilcox, Robert J. Allen, Camilla W. Stjern, Marianne T. Lund, Sharar Ahmadi, Annica Ekman, Maxwell T. Elling, Luke Fraser-Leach, Paul Griffiths, James Keeble, Tsuyoshi Koshiro, Paul Kushner, Anna Lewinschal, Risto Makkonen, Joonas Merikanto, Pierre Nabat, Larissa Narazenko, Declan O'Donnell, Naga Oshima, Steven T. Rumbold, Toshihiko Takemura, Kostas Tsigaridis & Daniel M. Westervelt

Communications Earth & Environment **6**, Article number: 543 (2025) | Cite this article

Article | Open access | Published: 14 July 2025

East Asian aerosol cleanup has likely contributed to the recent acceleration in global warming



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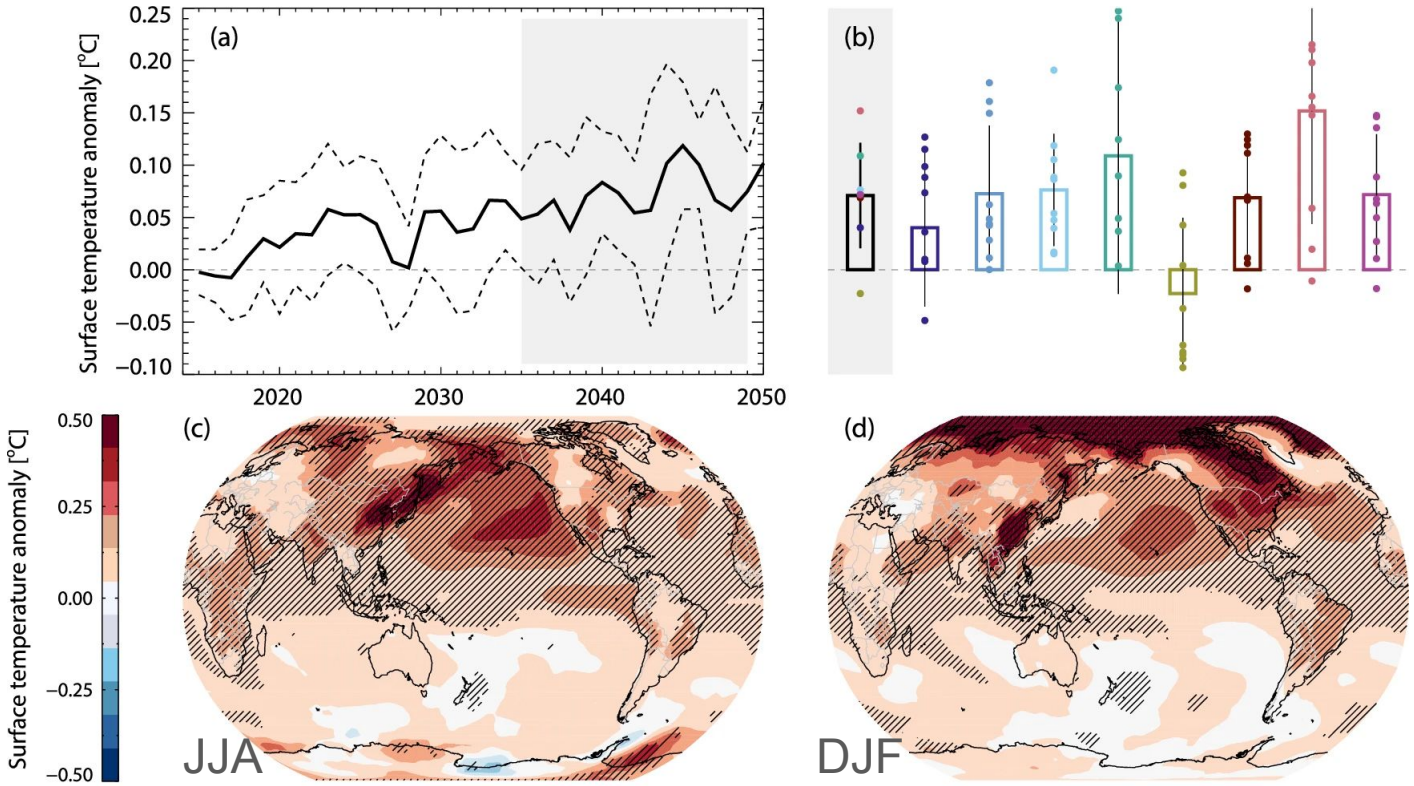


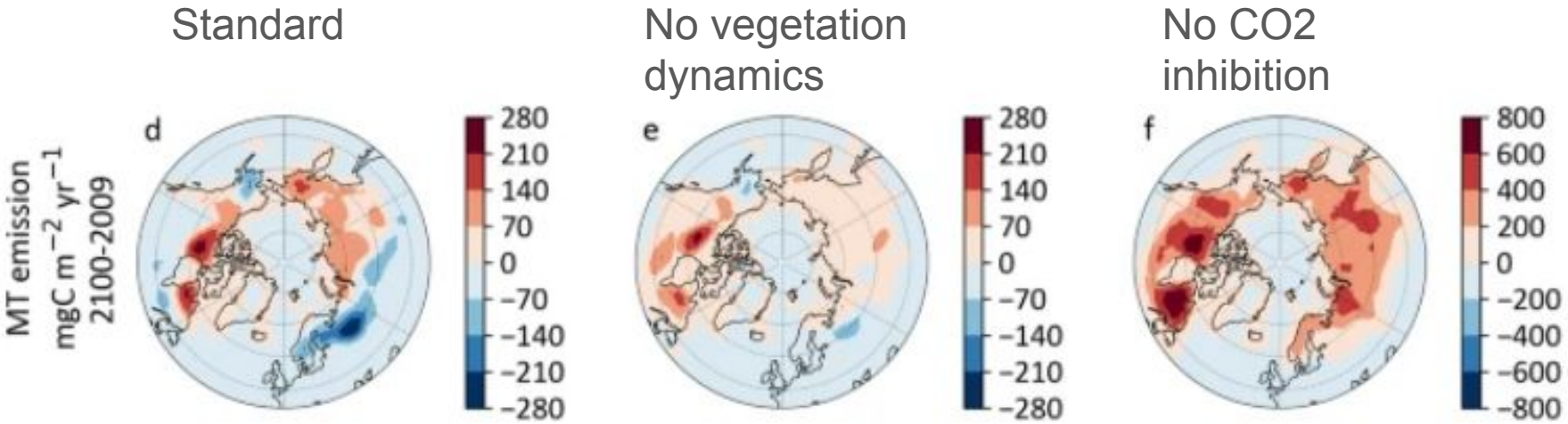
Biogenic feedback in high-latitudes

Over the Nordic countries and western Russia, the climate warming induced

- increase of broad-leaved deciduous trees
- decrease of boreal evergreen needle-leaved trees in the boreal forest region in future scenarios

→ Increase of biogenic isoprene emissions usually from broad-leaved trees and a decrease of biogenic monoterpene emissions from needle-leaved trees

Uncertainty in CO2 inhibition effect on BVOC emissions



Tang et al., 2023

Natural aerosol sources over the Arctic Ocean


Olaf Schneider

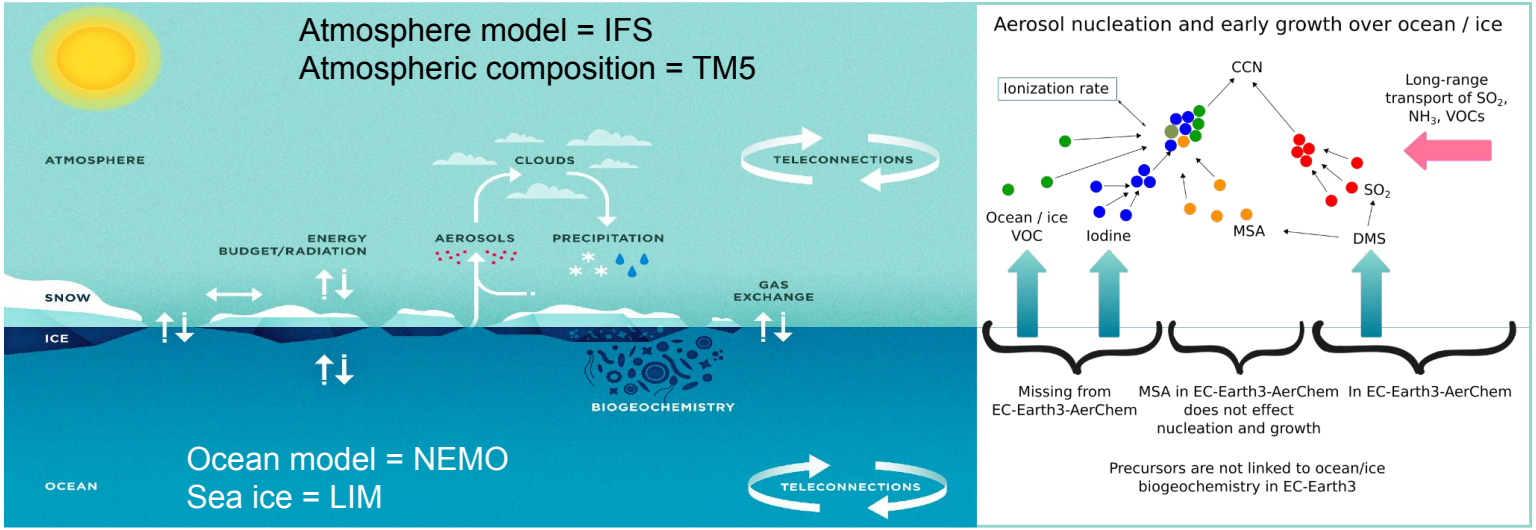

James Hannigan, UCAR


John Goodge, Univ. Minnesota

Primary aerosols (emited as particles) – sea salt, organics
Secondary aerosols (produced from gases) – dimethysulfide (DMS), organics, iodine

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

Polar aerosol in EC-Earth3 global Earth System Model



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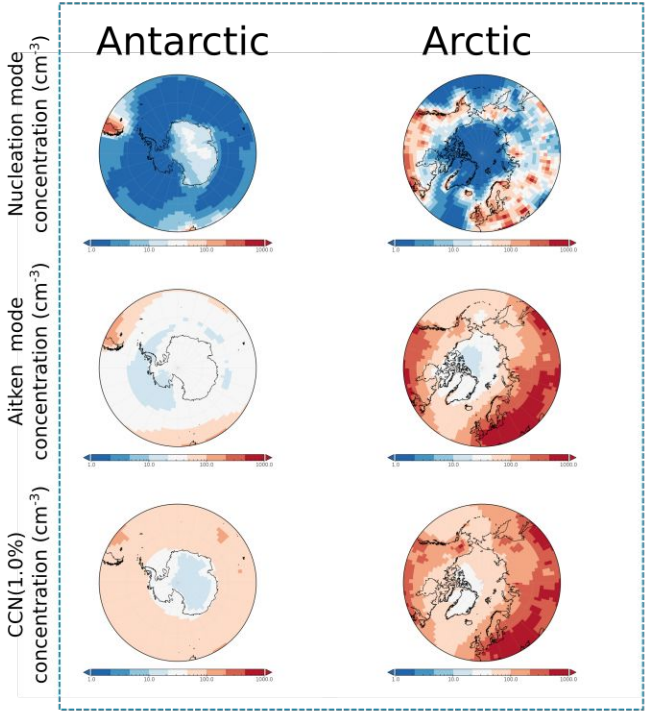
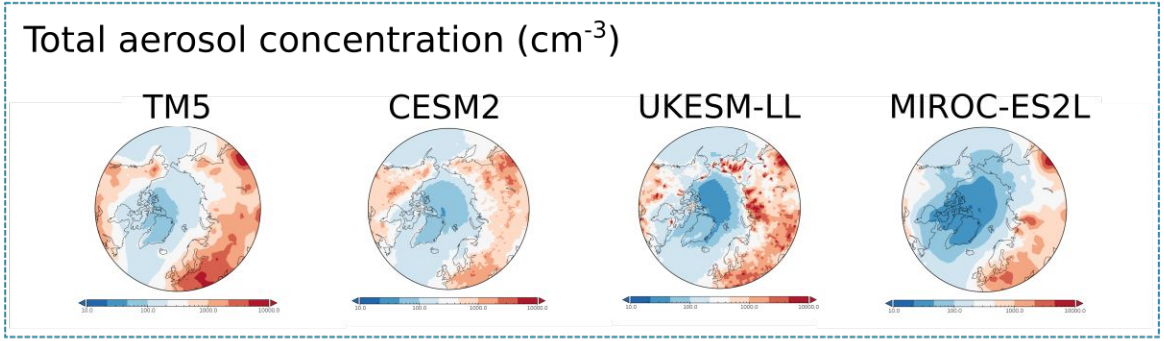
EC-Earth3 aerosol and CCN concentrations over the polar regions



Extremely low nucleation and growth rates throughout Arctic ocean and the Southern Ocean. Aerosols also transported downwards from higher altitudes at the poles.

Similar Arctic aerosol concentrations as in other CMIP6 models (below, plotted as *conccn* from ESGF)

Evaluation of polar aerosol concentrations remains difficult due to insufficient station observations and limitations in satellite remote sensing at high latitudes.



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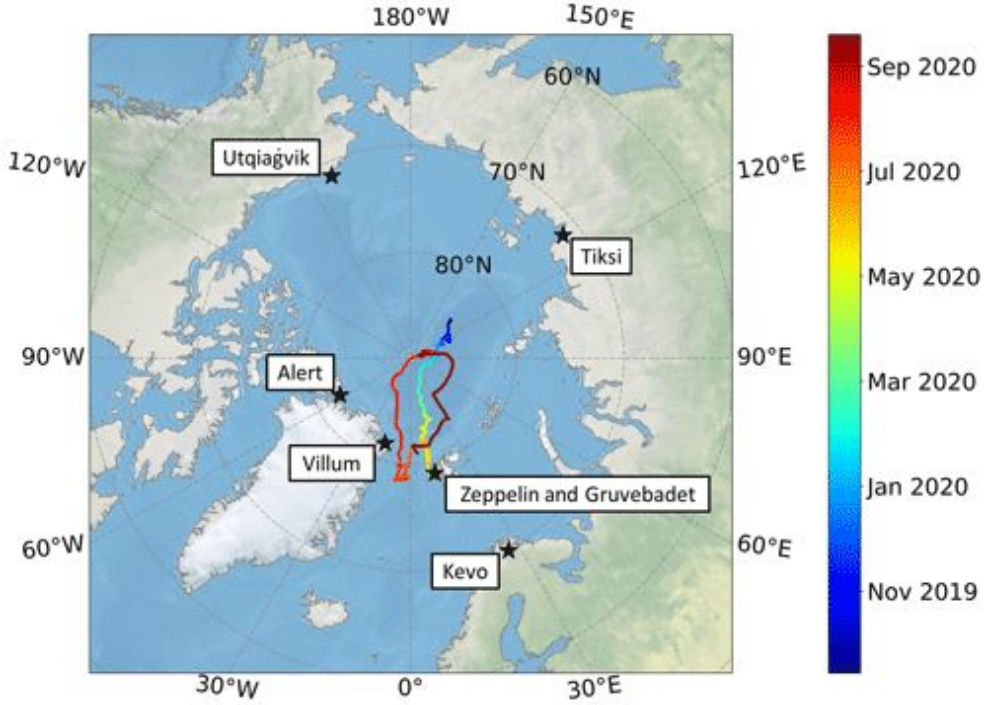
Simulating aerosols during MOSAiC campaign 2019–2020

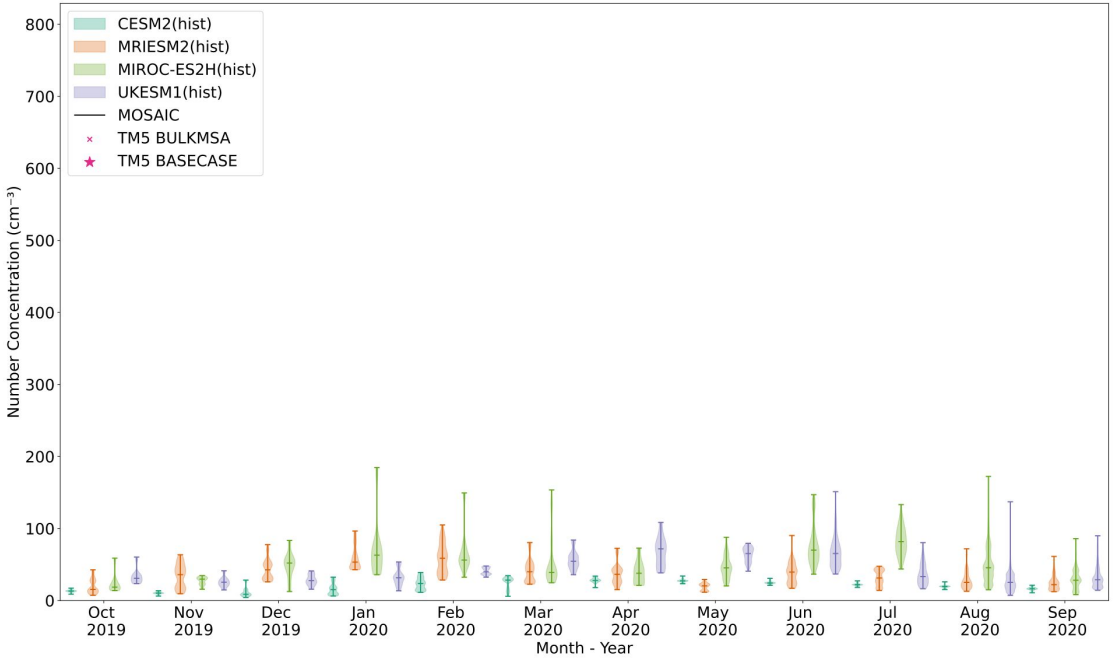


MOSAiC CN data: Beck, Ivo; Quéléver, Lauriane; Laurila, Tiia; Jokinen, Tuija; Schmale, Julia (2022): Continuous corrected particle number concentration data in 10 sec resolution, measured in the Swiss aerosol container during MOSAiC 2019/2020. PANGAEA.

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

Chandrasekharan et al., submitted

Arctic Aerosols in CMIP6 models



- CMIP6 models have low values. Monthly average values from 2005-2014 used

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FINNISH METEOROLOGICAL INSTITUTE

Chandrasekharan et al., submitted

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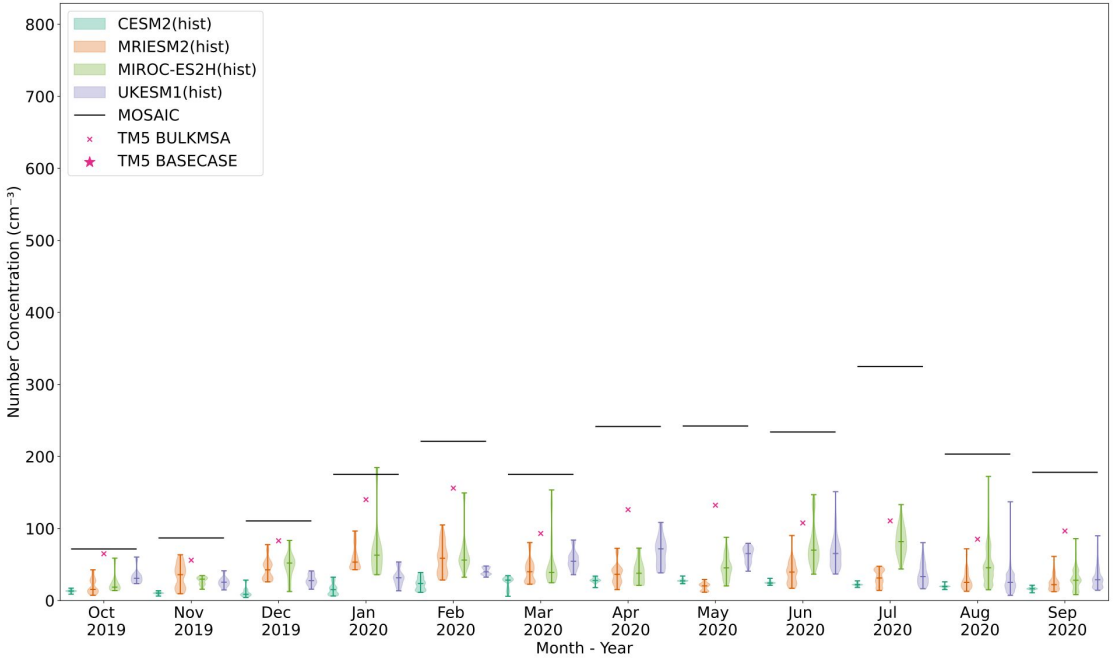

- CMIP6 models have low values. Monthly average values from 2005-2014 used
- TM5 (EC-Earth3-version) values very close to CMIP6 models
- MOSAiC observations are higher than the model output

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Chandrasekharan et al., in prep.

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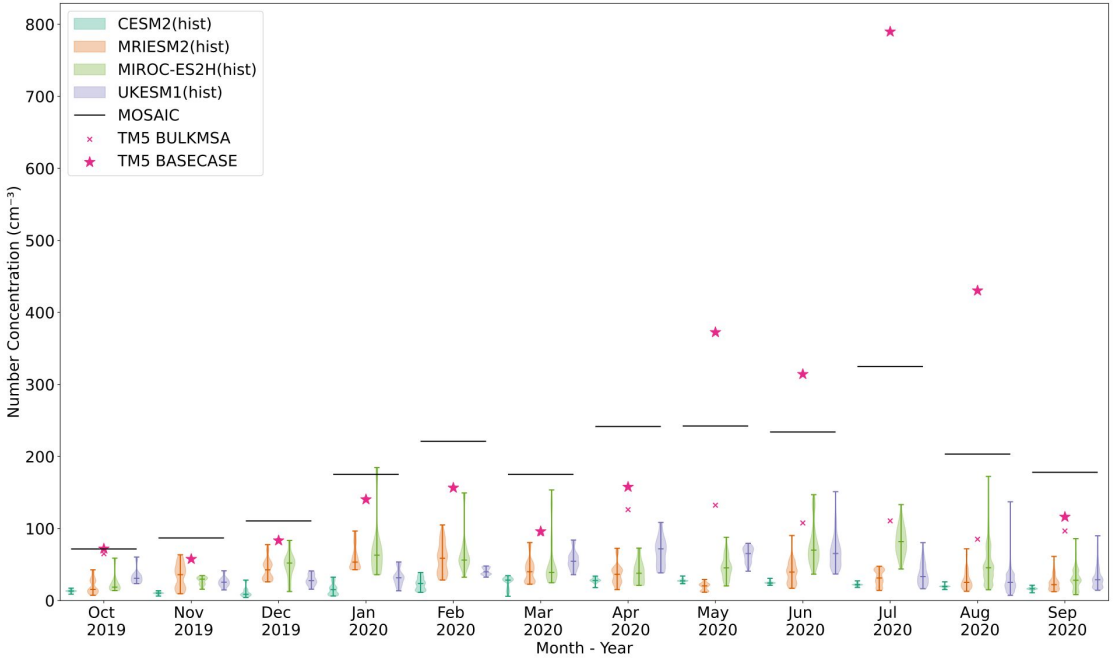

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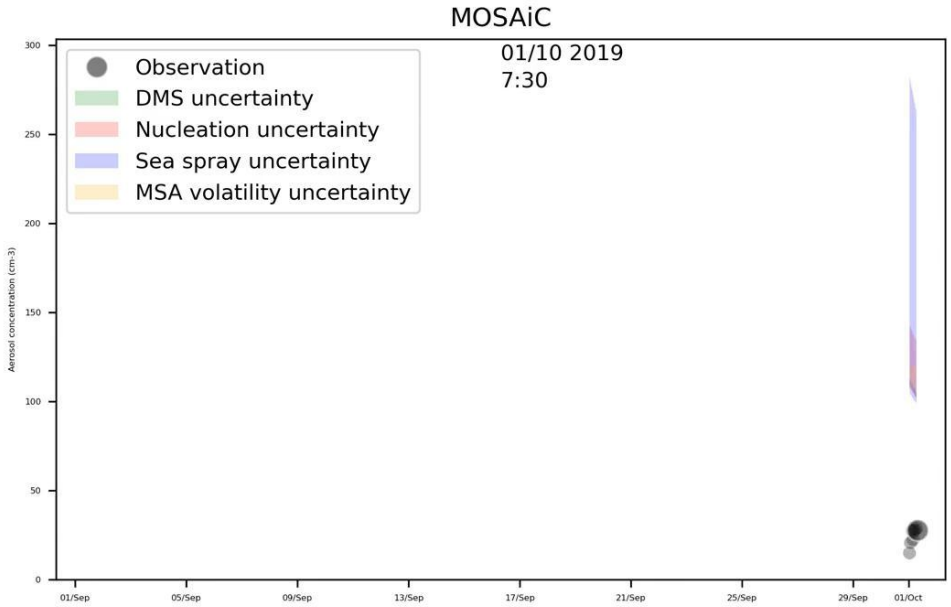
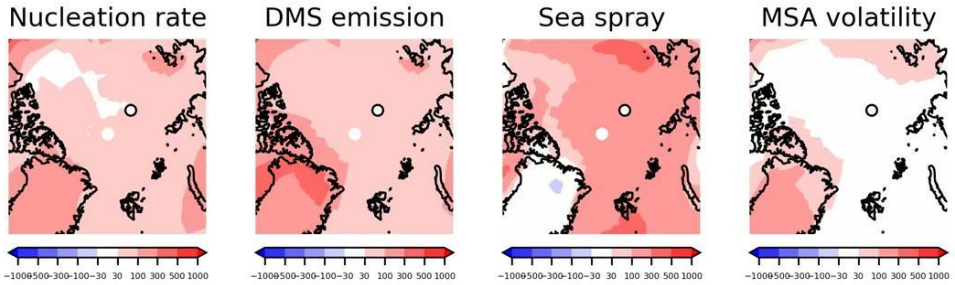


Chandrasekharan et al., in prep.



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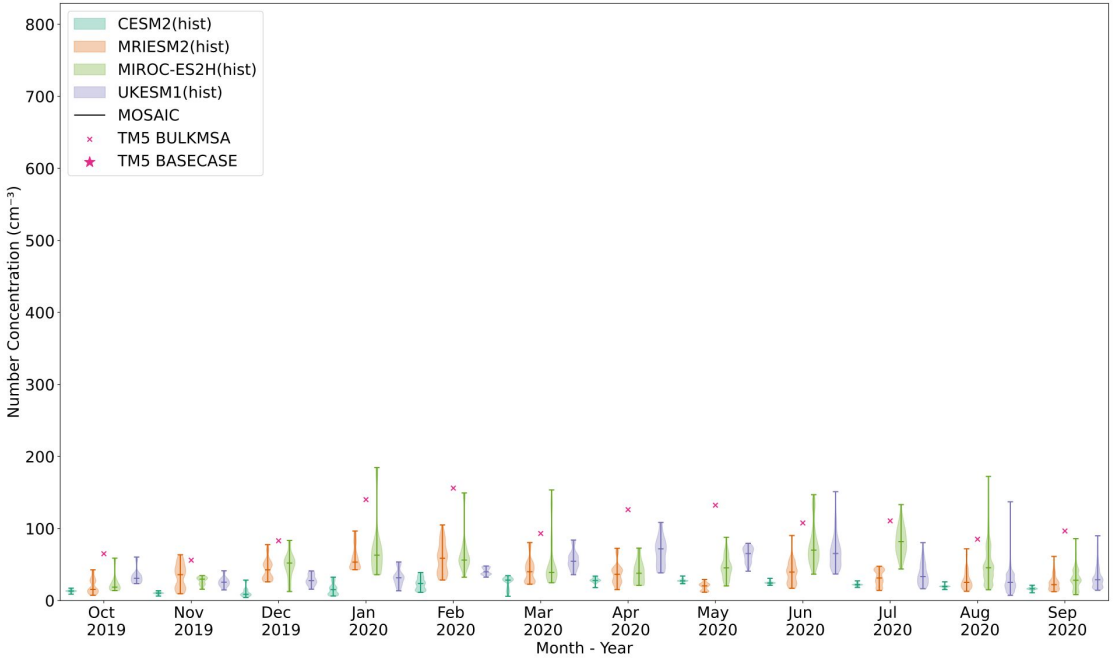

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Chandrasekharan et al., submitted

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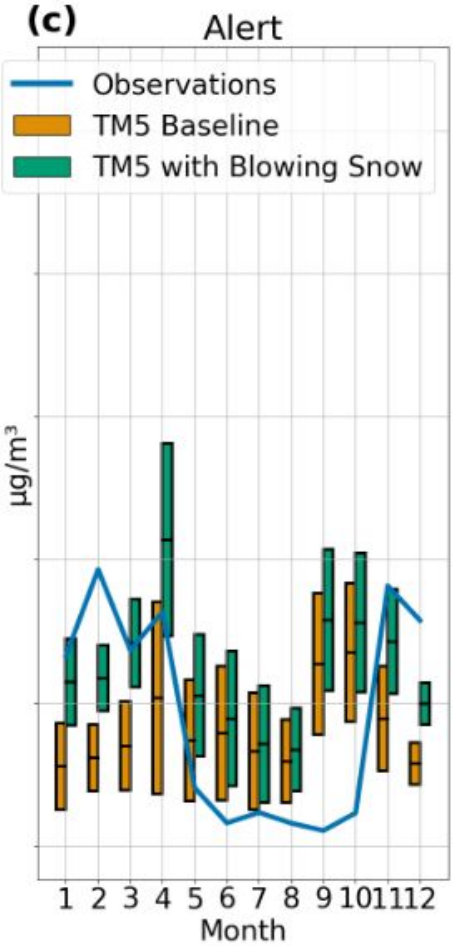
Newly implemented process in EC-Earth: Blowing snow

- Blowing snow is an important source of sea salt aerosols (SSA) in polar regions, which is often underrepresented in climate models
- A new parameterization for blowing-snow SSA was implemented in the TM5 and EC-Earth3 models to better capture this process
- The scheme was evaluated against observations (e.g., MOSAiC campaign and Arctic stations), providing real-world validation
- Including blowing snow substantially increases simulated SSA concentrations, especially in Antarctica
- This leads to improved agreement between models and observations, indicating better representation of polar aerosol processes.
- The results suggest important implications for radiative forcing and climate simulations in polar regions



Nordling, K., Merikanto, J., Räisänen, P., Chandrasekharan, A., and Makkonen, R.: Sea Salt Aerosols from Blowing Snow: Contributions to Radiative Forcing, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2026-1575, 2026.

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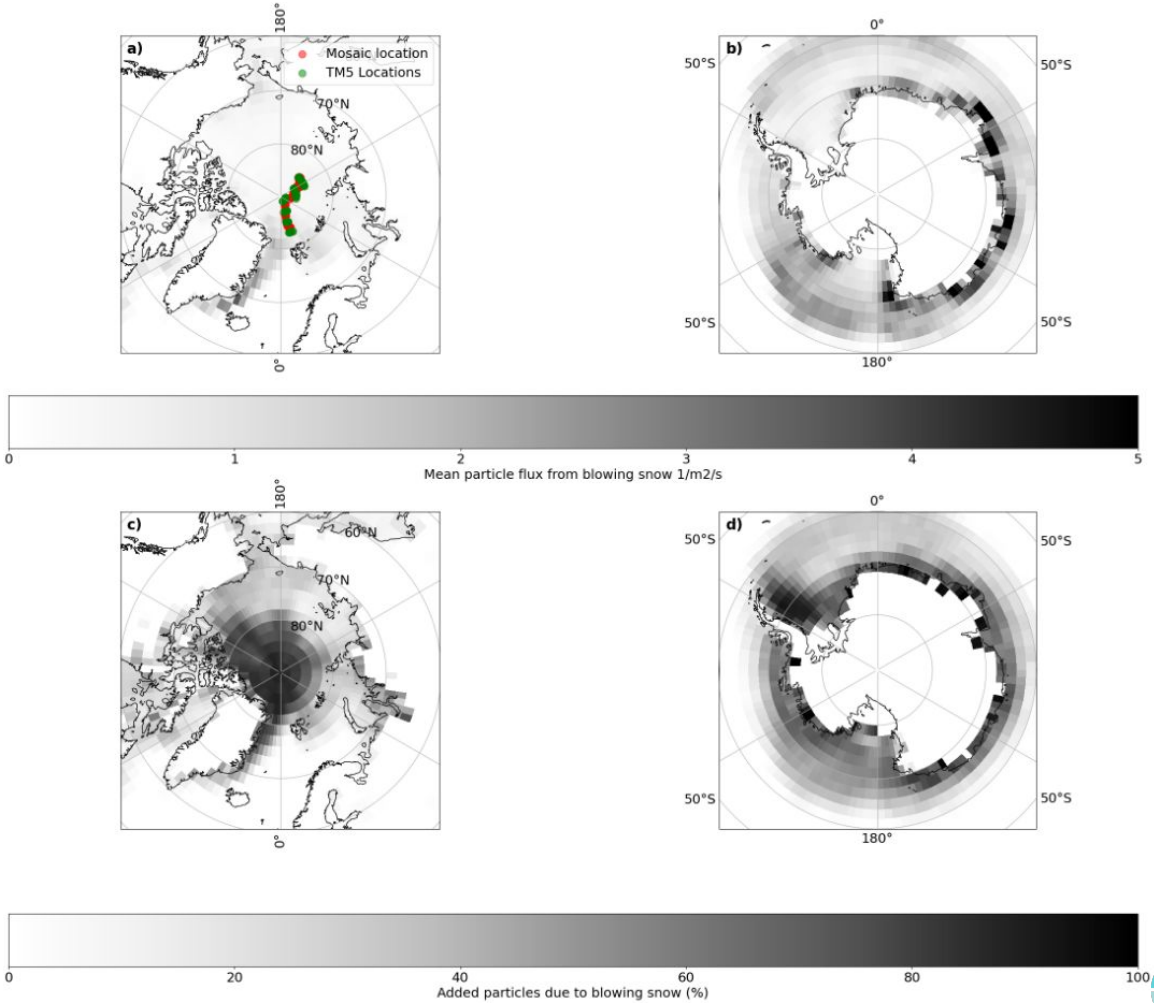

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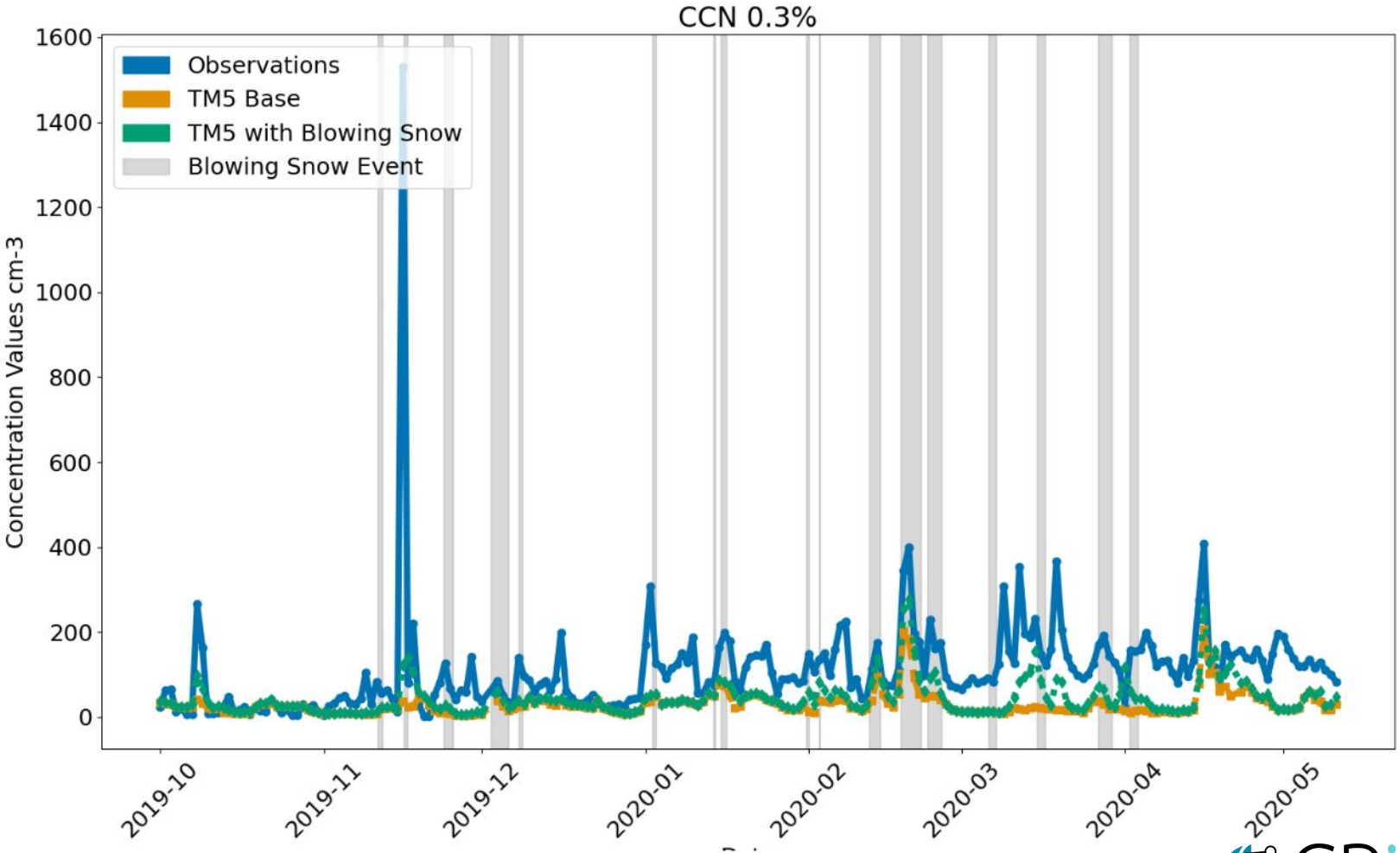

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