Climate **R**elevant interactions and feedbacks: the key role of sea **ice** and **S**now in the polar and global climate system

CRiceS

Updates from CRiceS project

PEEX Event
14 April 2026

Risto Makkonen (FMI)

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

Climate **R**elevant interactions and feedbacks: the key role of sea **ice** and **S**now in the polar and global climate system

CRiceS

Overview of CRiceS

***C**limate **R**elevant interactions and feedbacks: the key role of sea **ice** and **S**now in the polar and global climate system (CRiceS)*

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

Overview

Coordinator:
Risto Makkonen, FMI (Finland)

Scientific coordinator:
Jennie Thomas, IGE/CNRS (France)

Duration: Sept. 2021 - Nov. 2025

H2020 Call:
LC-CLA-17-2020 - Polar climate: understanding the polar processes in a global context in the Arctic and Antarctic Regions

https://www.crices-h2020.eu

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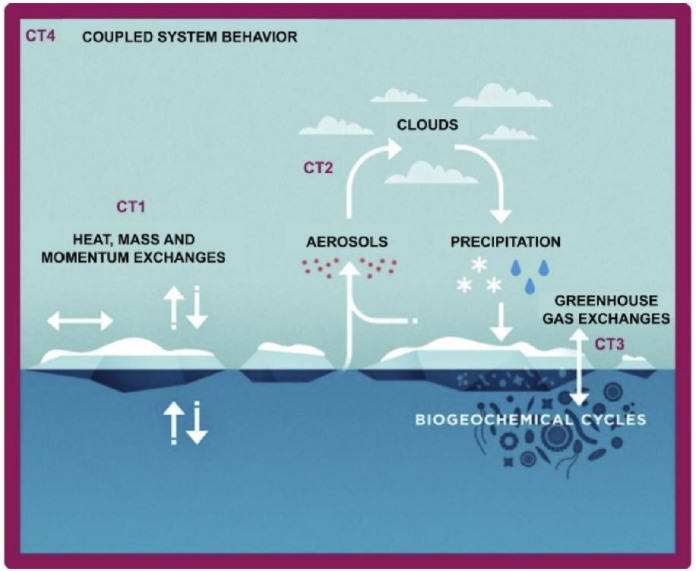
Core themes

CT1. Heat, mass and momentum exchanges

CT2. Aerosols & clouds

CT3. Biogeochemical cycles/greenhouse gas exchange

CT4. Integrated system understanding



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Recent policy events

#1 Policy webinar: The importance of European scientific leadership in polar climate change
Thursday 27 November 2025,
13:00-14:30 CET, **online**
Kalle Kankaanpää, Ambassador for Arctic Affairs
Aili Keskitalo, incoming member to the UN Permanent Forum on Indigenous Issues
Larisa Lorinczi, Policy Officer at the European Commission
Peter Sköld, Chair of the European Polar Board

#2 Policy event: Polar Science for Global Action: Strengthening Climate Preparedness through EU Leadership
Tuesday, 18 November 2025, 09:00–11:00, Brussels and online
Sakis Arnaoutoglou, Member of the European Parliament
Larisa Lorinczi, Policy officer, DG RTD, European Commission
Martin Wearing, Digital Twin Earth Scientist, European Space Agency

Info and registration: www.crices-h2020.eu/home

Climate **R**elevant interactions and feedbacks: the key role of sea **ice** and **S**now in the polar and global climate system

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CRiceS results relevant to CMIP7 and IPCC

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CT1:
Heat, mass and momentum exchanges

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CT1 : Energy Exchanges

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Sea ice deformation, fracturation, rheology

Observation-based results on sea ice fracturation, lead formation (MOSAiC), impact of cyclones… Assessment of different rheologies

Ocean and atmosphere large-scale circulation and heat transport

Comparison model/observation on water masses circulation, Atlantification, atmosphere heat exchanges

Virginie Guemas and co-authors

Snow (albedo, light transmission)

Intermediate-complexity snow model on ice with metamorphism, advanced snow properties, density, light transmission per spectral band, conductivity

Turbulent exchanges in the ocean and the atmosphere

Observation-based results on drag coefficient uncertainties, use for parameterization recalibration, new machine-learning based parameterization

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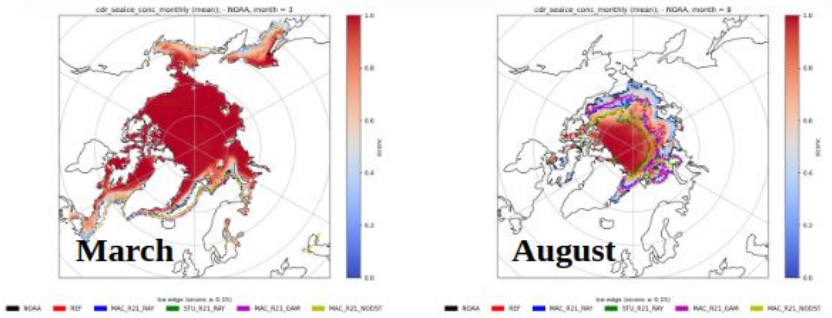
CT1 : Snow on ice (CNRS)

Brivoal et al (2025)

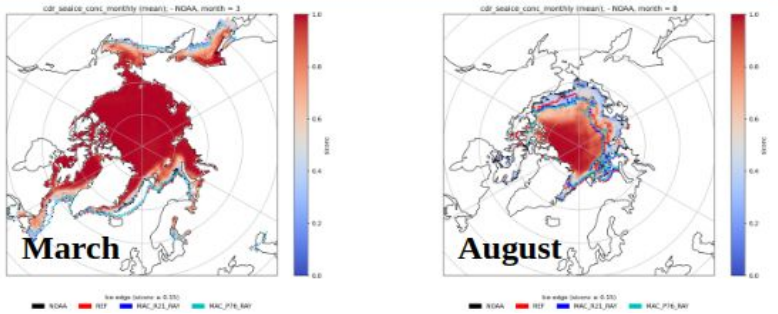
Box model replaced with intermediate complexity snow scheme (multi-layer, compaction, evolving density, albedo, conductivity, melting, refreezing)

30-year NEMO4.2-SI3 simulations (1990 - 2020) under JRA forcings, with the new snow scheme.

Impact of conductivity parametrization



Impact of snowfall density & wind compaction parametrization



Large impact of thermal conductivity formulation on the summer sea ice cover

Validation against observations in progress

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CT1 : Young Ice Parameterization (UCT/CMCC)

Mangatane et al submitted to JGR:Oceans

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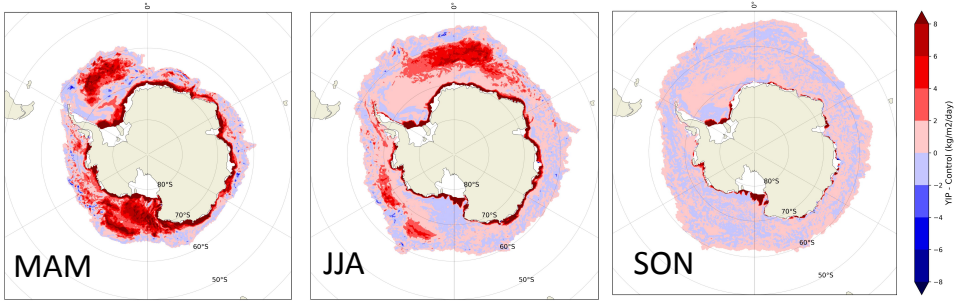
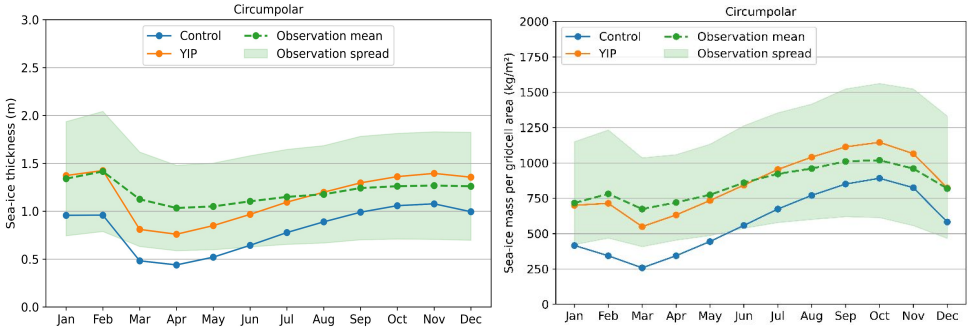
Parameterization as a function of salinity (proxy for high thermal permeability)

2016-2020 ocean sea ice simulations (NEMO4.2-SI3) with 0.25 deg resolution forced with ERA5

Impact of parameterization on new ice production



Evaluation against satellite-derived estimates



2016-2020 average: more winter ice production - corrects persistant summer bias
Also better polynyas representation

Needs evaluation of the ocean response, limited by field data

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CT2:
Aerosols & clouds

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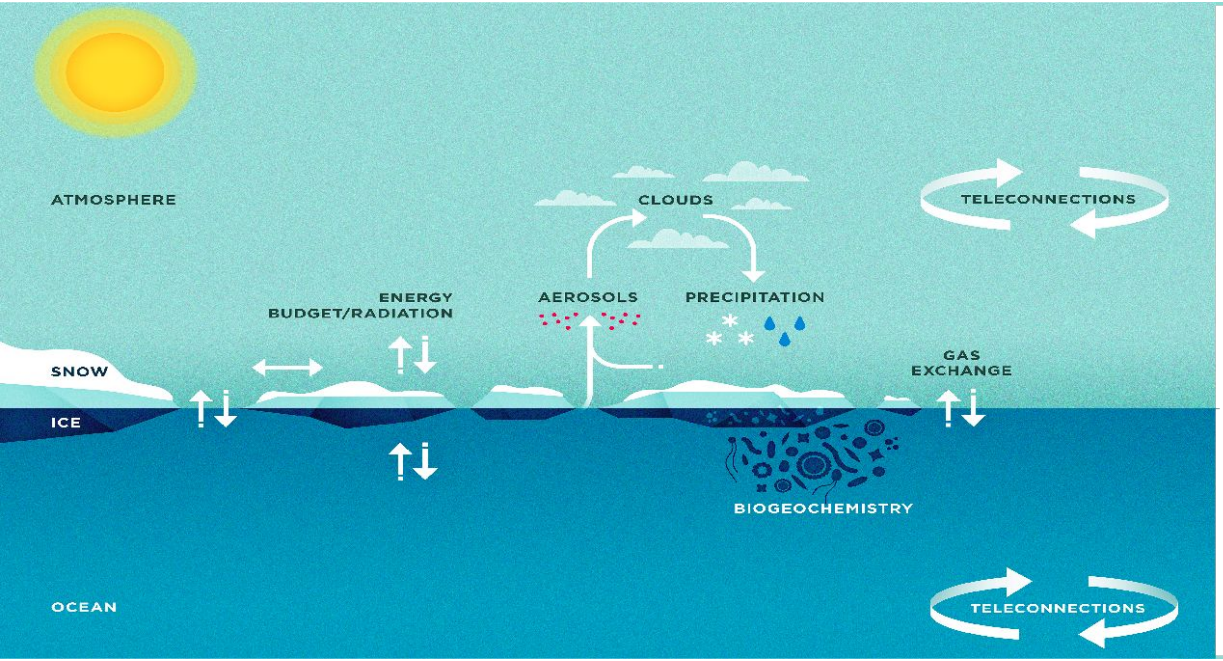
CT2 : Polar aerosols and clouds



Improved understanding of sources, sinks and impacts of polar aerosols, as well as aerosol-cloud mediated climate feedbacks within polar systems.

Contrasting polar aerosols regimes

Primary aerosol ⇄ Secondary aerosol

Natural ⇄ Anthropogenic

Present-day ⇄ Ice-free conditions

Regional sources ⇄ Long-range transport

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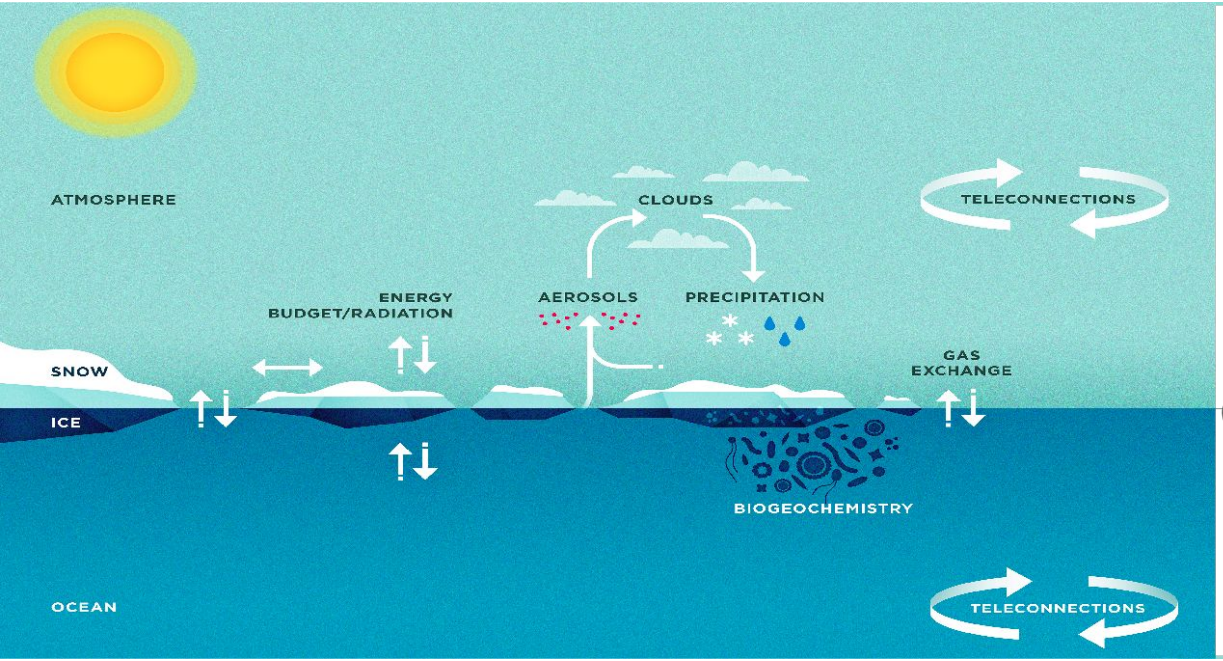
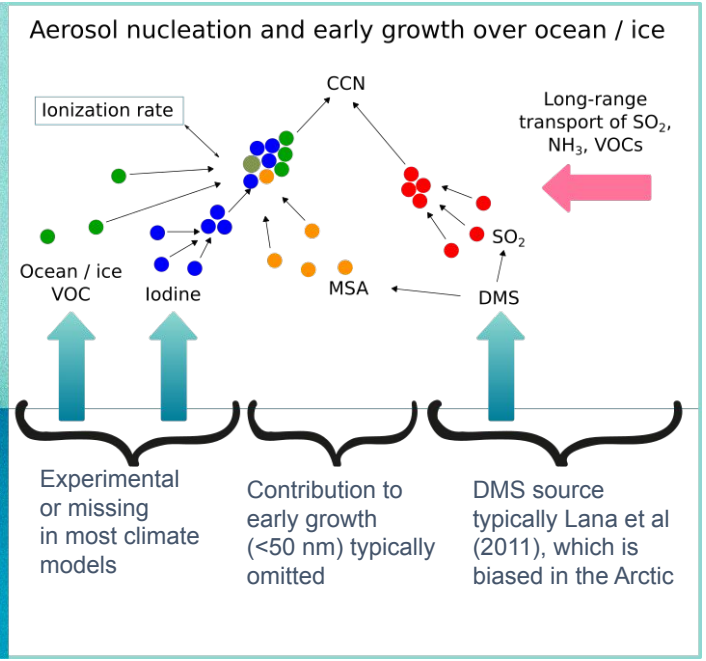
CT2 : Polar aerosols

Secondary aerosol formation





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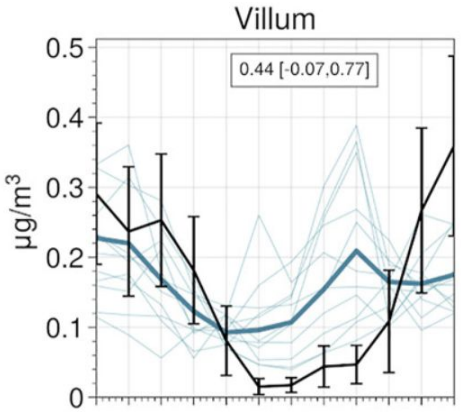
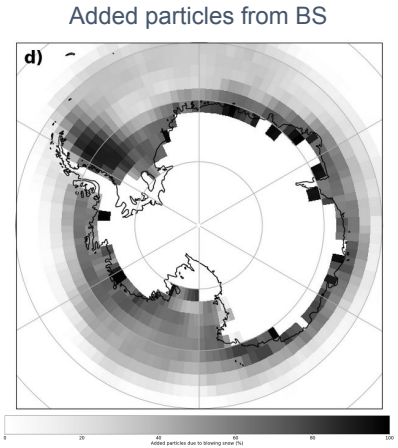
CT2 : Polar aerosols

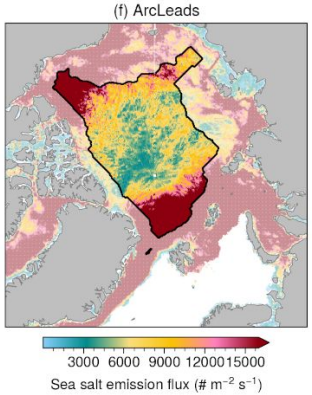
Primary aerosol sources



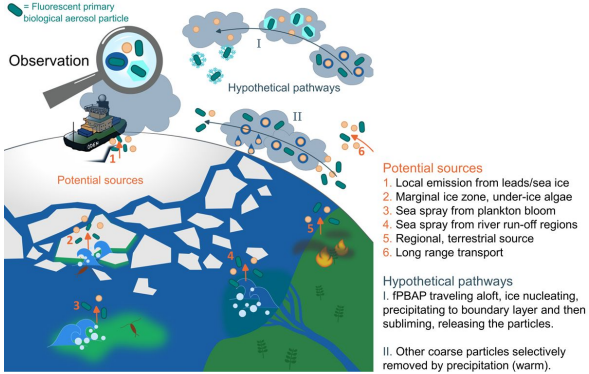
Sea spray
(Lapere et al., 2023)



Blowing snow aerosol
(Nordling et al., 2025, in prep.)



Sea spray from leads
(Lapere et al., 2024)



Polar PBAPs
(Kojoj et al., 2024)

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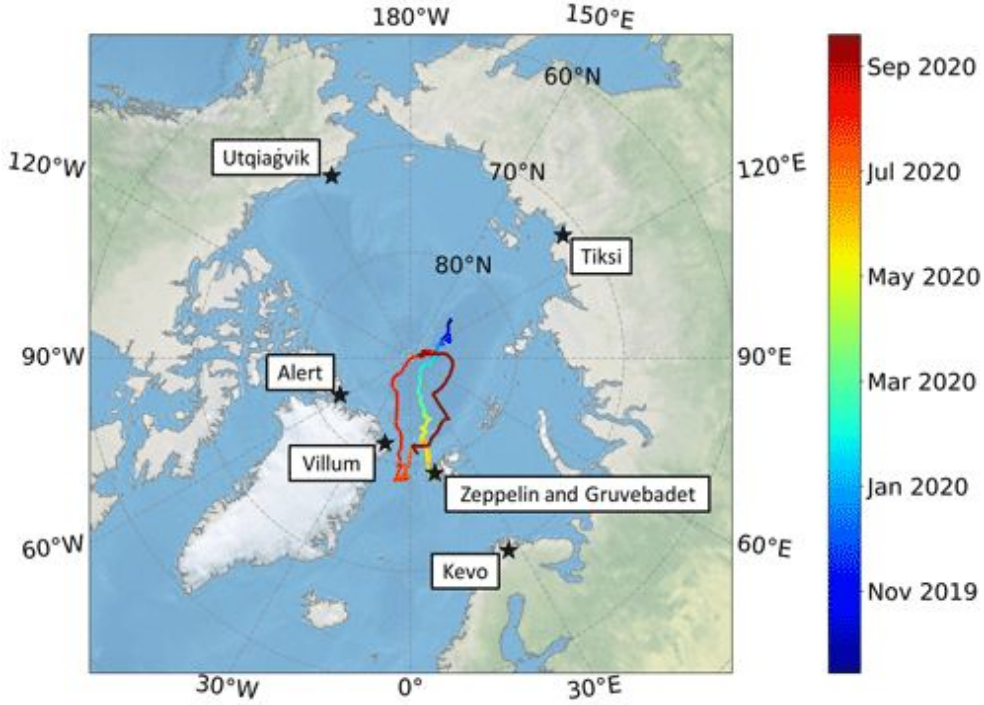
Simulating aerosols during MOSAiC campaign 2019–2020



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.

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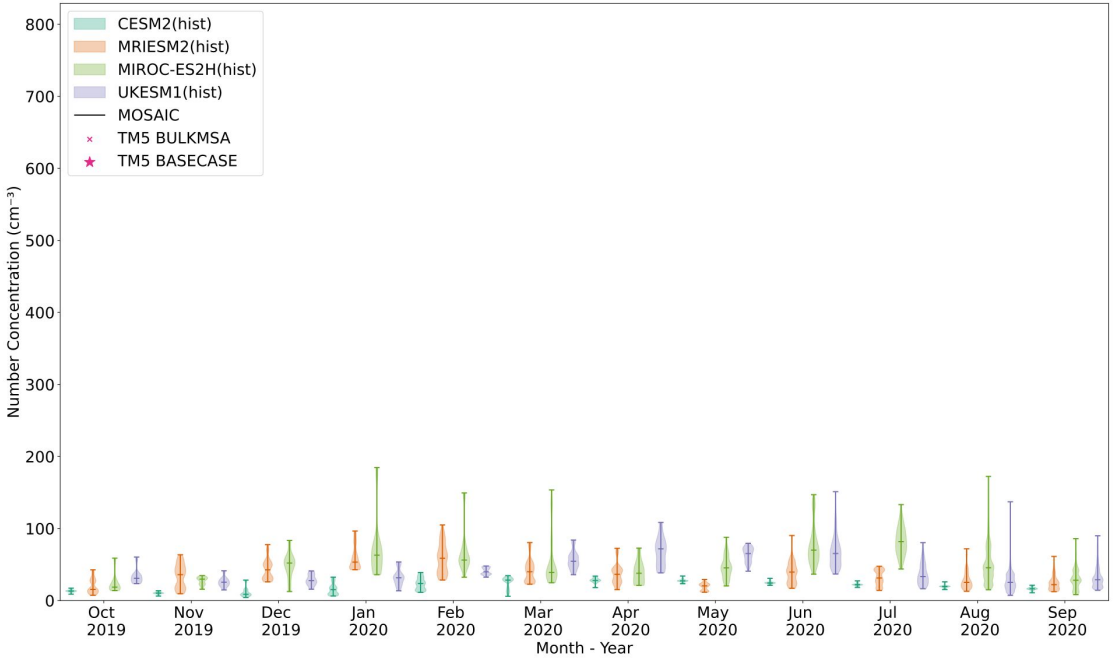
Chandrasekharan et al., submitted

Arctic Aerosols in CMIP6 models



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

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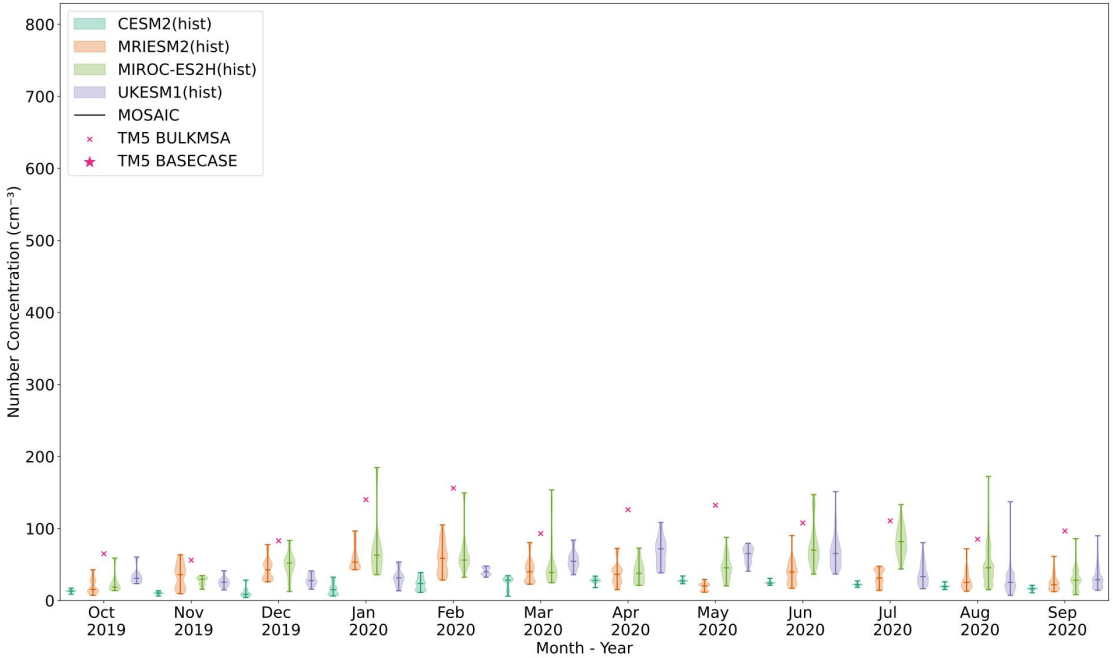

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- TM5 (EC-Earth3-version) values very close to CMIP6 models

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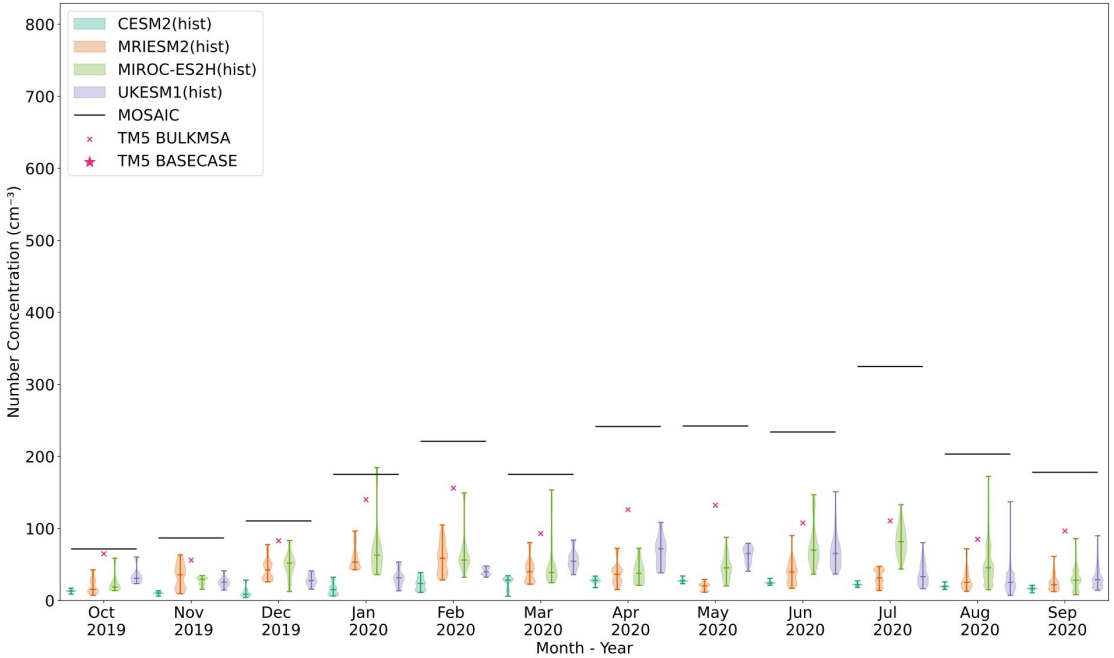

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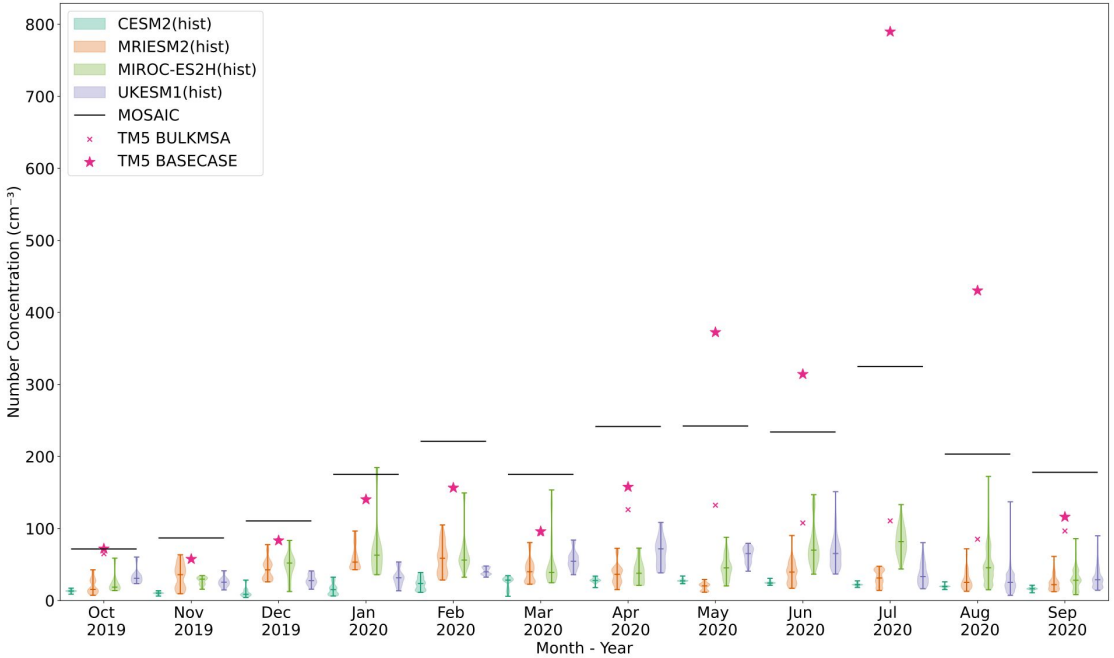

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CT3: Biogeochemical cycles & greenhouse gas exchange

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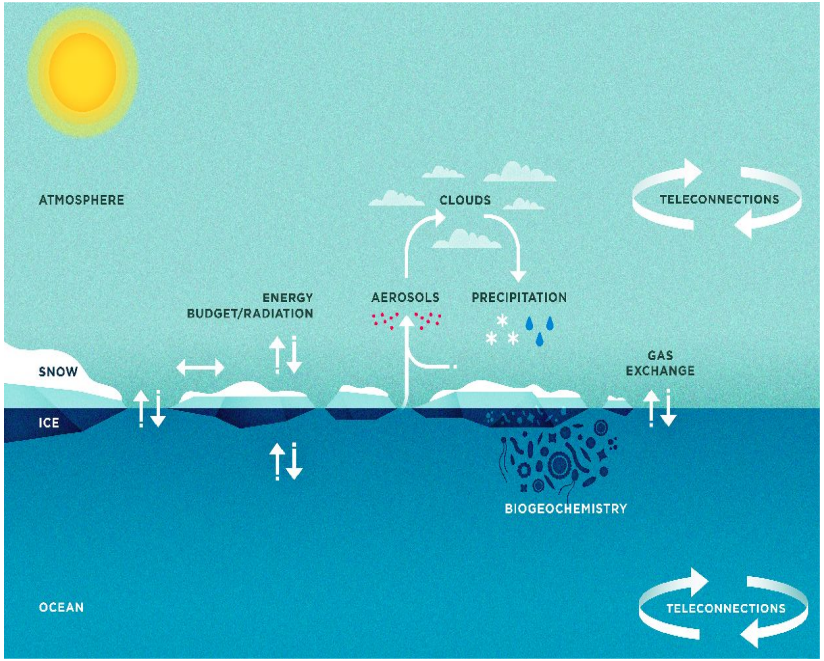
CT3 Objectives



- **Improve biogeochemical processes and gas exchanges** between the ocean, sea ice, snow, and atmosphere **in models** (poorly represented/captured in Earth System Models).
- **Develop new model descriptions** of how sea ice and snow affect the exchange of gases, aerosols (linking to CT2), nutrients, and carbon between the atmosphere and the ocean.
- Work spanned **process understanding → model development → Earth system integration**.
- **Test and quantify the influence of improved polar biogeochemistry** (effects on CO_2 uptake, ocean acidification, deoxygenation, nutrient transport, and primary production) to better represent global climate feedbacks.

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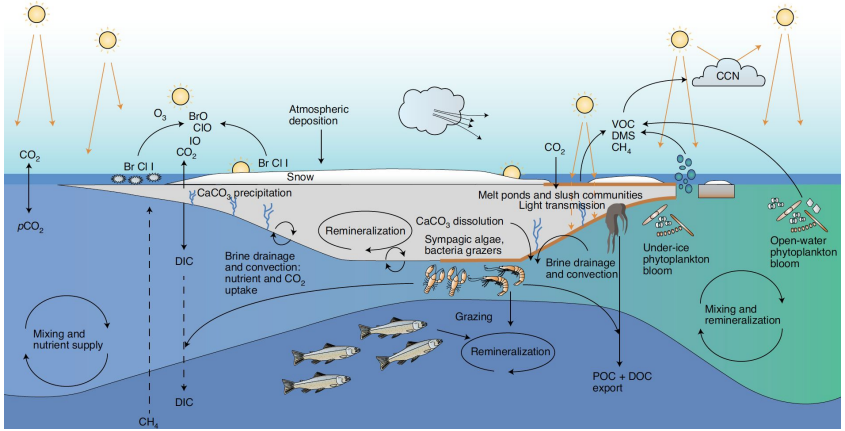
CT3 Main developments within ESM



(Lannuzel et al, 2020)

- **Improved air–sea CO_2 exchange under partial ice cover** → reduces global CO_2 ocean uptake by ~9%.
- **Dynamic sea-ice biogeochemistry** → enhances under-ice productivity and strengthens carbon export (+5–8%).
-

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