Over the edge: Semi-Lagrangian cloud phase changes in mixed-phase clouds across the marginal sea ice zone

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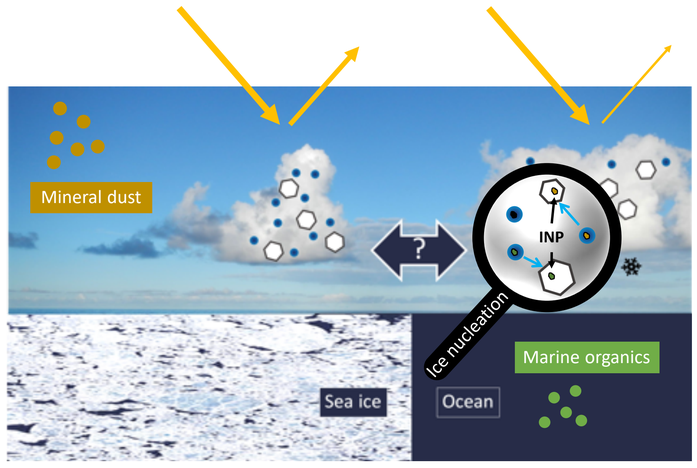
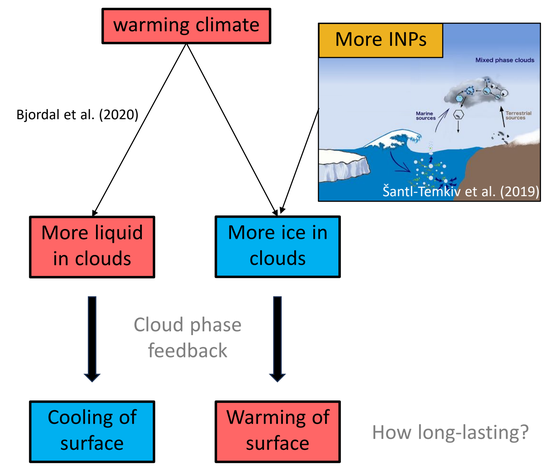
Cloud phase influences radiative effect, precipitation formation, and cloud lifetime.



Ice formation

Ice-nucleating particles (INPs) needed for initial ice to form (e.g., Mineral dust, Marine organics)

How does cloud phase change with warming?



Objective:

How does sea ice influence cloud phase?

Cold Air Outbreaks (CAOs) provide us with a natural laboratory.
To disentangle the surface influence, we use semi-Lagrangian cloud tracking from satellite.

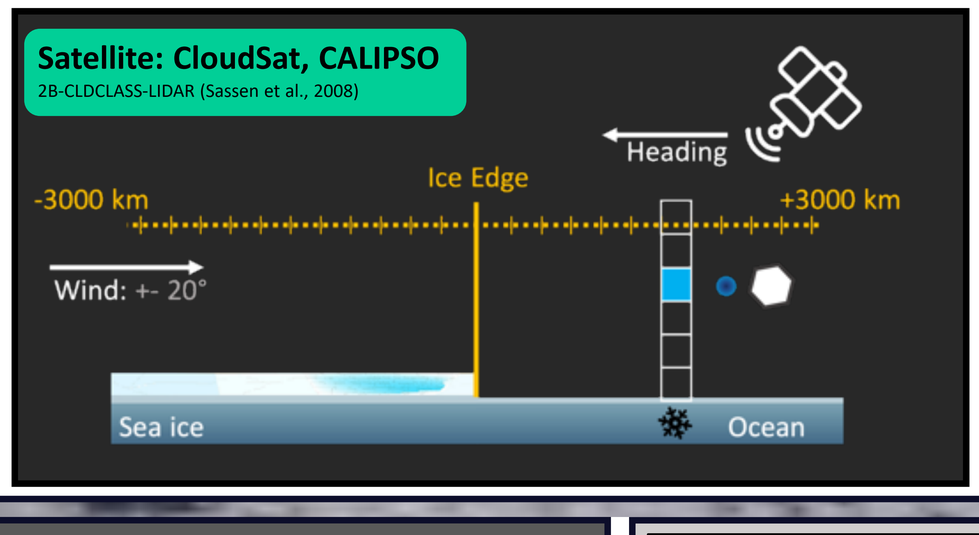
Methods: cloud tracking

Data: Winter (JJA 2007-2010)

- Cloud phase (**liquid**, **mixed**, **ice**)
- Cloud top temperature
- Cloud top height
- Precipitation flag
- Sea ice concentration (Spreen et al., 2008)

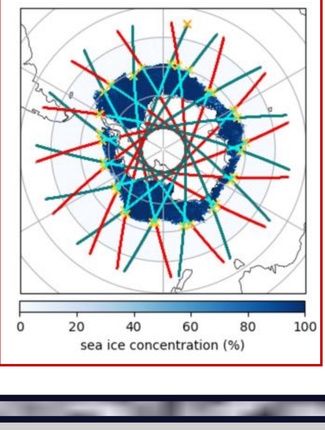
Semi-Lagrangian tracking:

- CloudSat/CALIPSO overpasses that were aligned within +-20° of mean wind

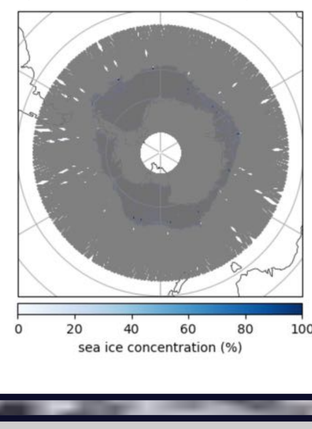


Sea ice
x ice edge

Semi-Lagrangian
(Taylor and Monroe, 2023)



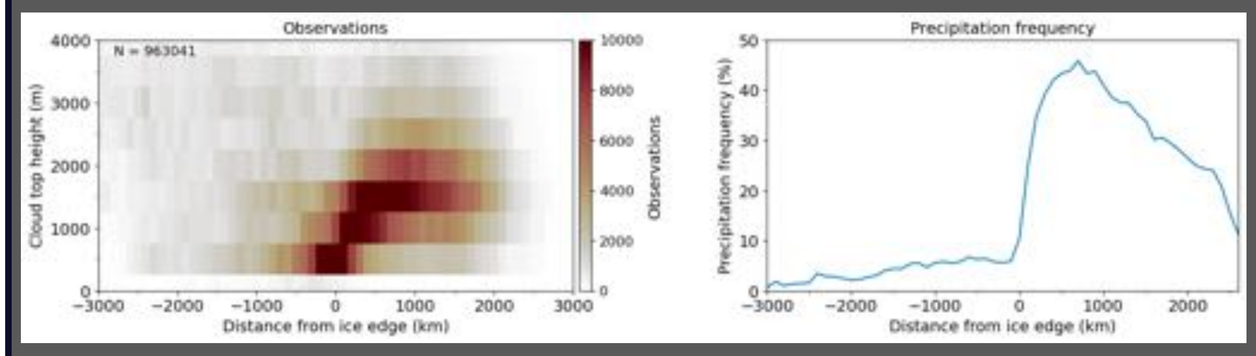
Eulerian approach
(Carlsen and David, 2022)



Background: NASA Earth Observatory

Cloud evolution: off-shore

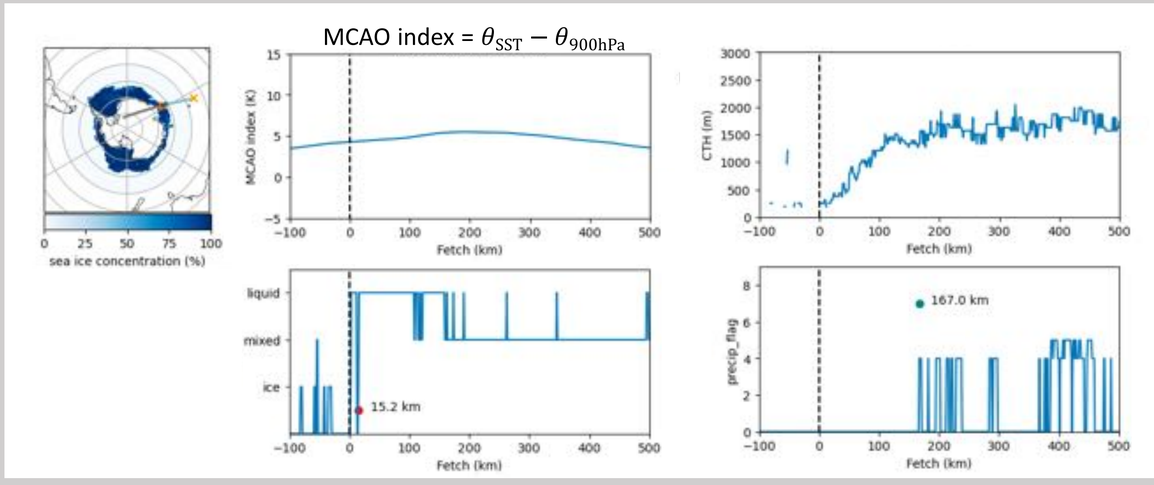
Wind
Cold Air Outbreak
Sea ice Ocean



Cold Air Outbreak evolution: strong energy fluxes from warm ocean lead to…

- cloud formation (rising cloud top heights with deepening boundary layer),
- precipitation formation.

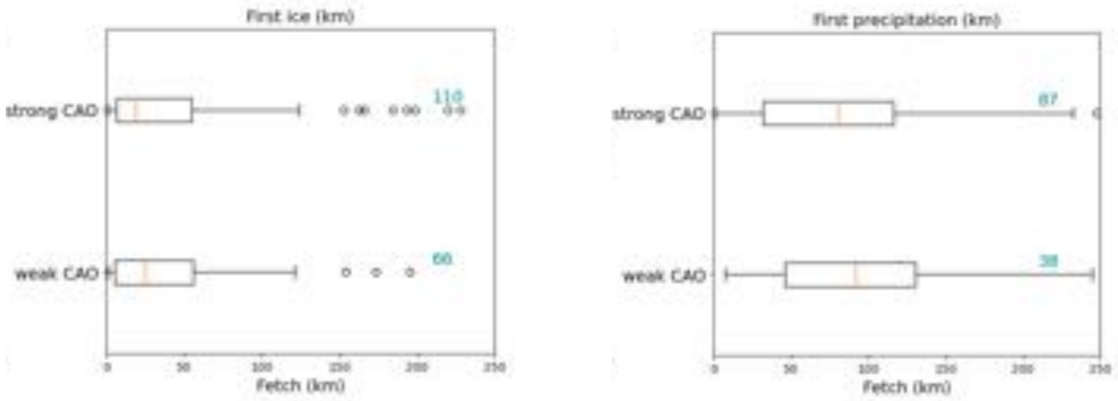
Track-by-Track: CAO case June 2007



Top: Satellite track, MCAO index, and Cloud top height (CTH) for CAO case in June 2007
Bottom: **first ice** in cloud 15.2 km from sea ice edge, **first precipitation** after 167 km

Track-by-Track: All CAOs (winter, JJA)

weak CAO: MCAO index < 4K
strong CAO: MCAO index > 4K

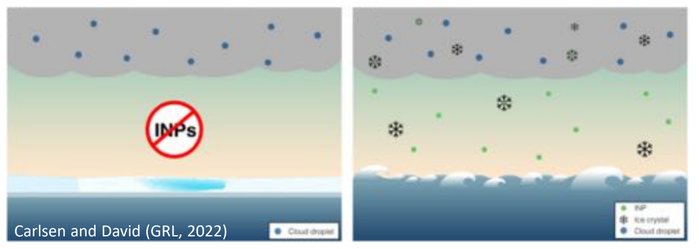


Statistics of first ice and first precipitation in clouds for all CAOs in winter (JJA):

- only weak dependence of cloud phase evolution on CAO index
- weak dependence of precipitation formation on CAO index

In a nutshell

Carlsen and David (2022): Sea ice acts as a lid and **limits availability of marine organic INPs.**
But how important is secondary ice?



This study: Semi-Lagrangian cloud tracking of CAOs with satellite reveals **only weak (?) dependence of cloud phase evolution on CAO index.**
Do INPs control cloud phase?

What will happen in a warming world with retreating sea ice?

We are happy to discuss our results offline, please contact us!
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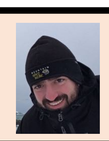

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