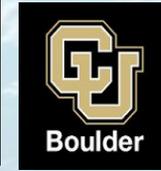
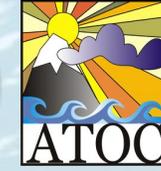


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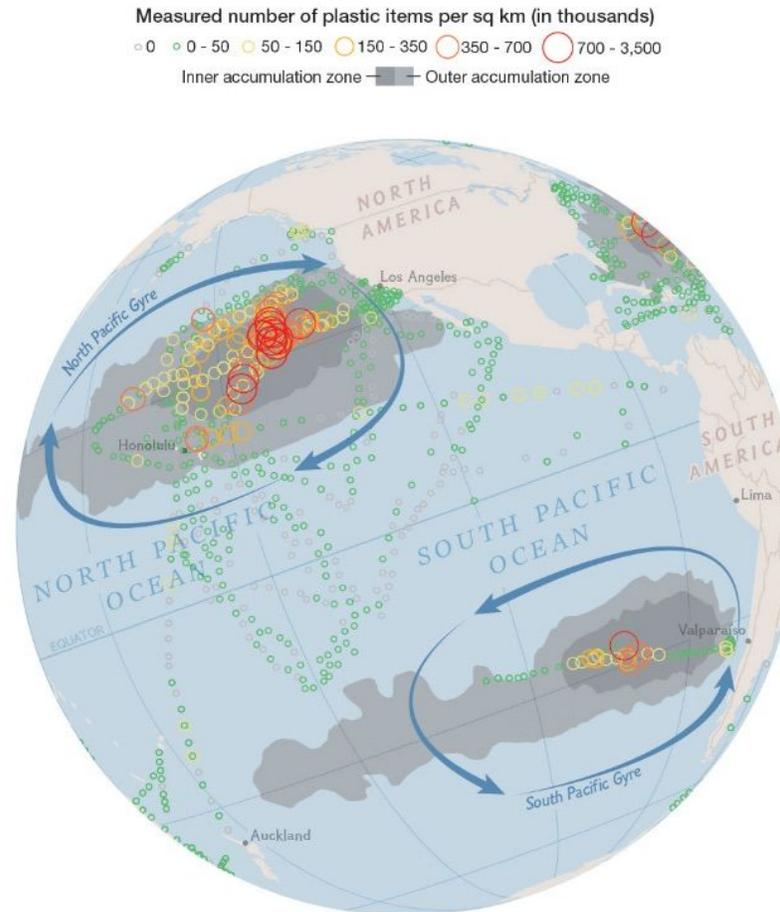
Insights into the Arctic Ocean-Sea Ice Exchange of Microplastics in the CESM2

Lingwei Li, Alexandra Jahn, David A. Bailey, Michael Steele

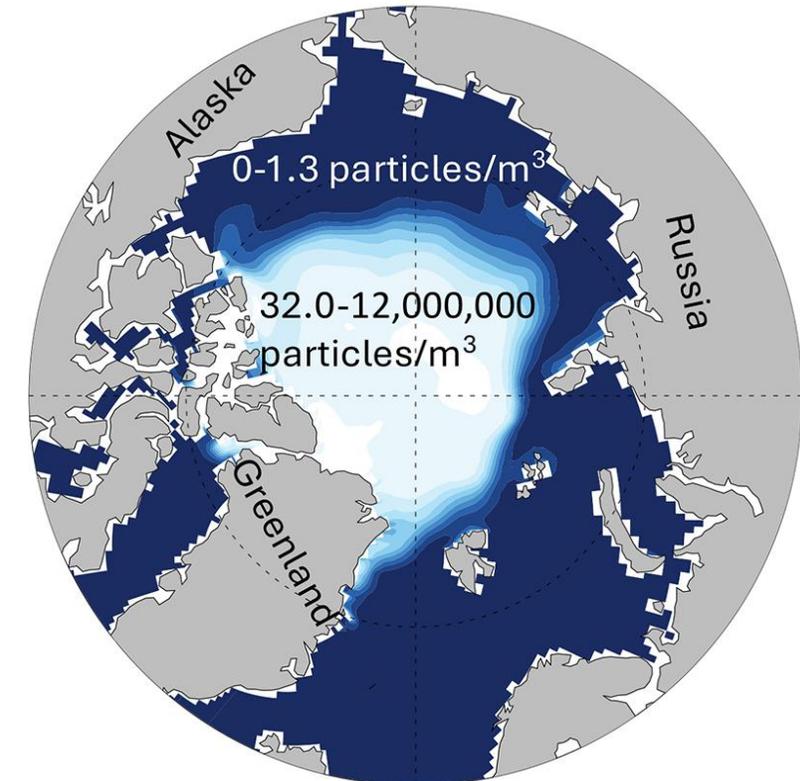
Institute of Arctic and Alpine Research (INSTAAR)
University of Colorado Boulder

Microplastics (MPs) in the Arctic

- MPs are now prevalent in global oceans and substantial MPs are even found in the remote Arctic region.
- **Concentrations of MPs in the Arctic sea ice are ~1-6 order of magnitude higher than in underlying Arctic ocean.**
- The reasons for its high concentrations in the Arctic sea ice are still a mystery.



Map: Jamie Hawk,
National Geographic



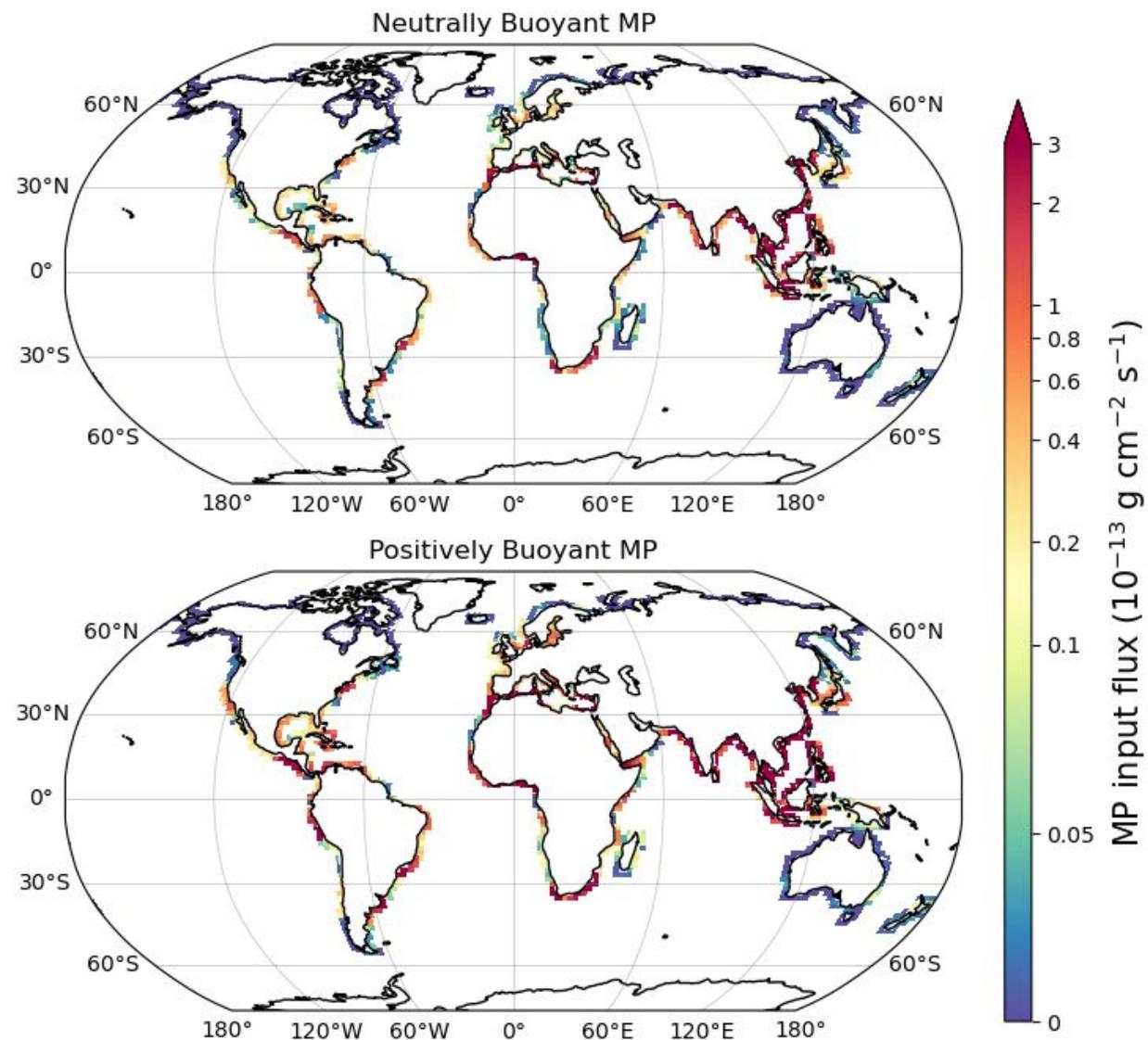
The numbers refer to the abundance of MPs in Arctic sea ice and underlying ocean (Bergmann et al., 2022)

Guiding scientific questions

1. What is the role of sea ice formation and melt in enriching Arctic sea ice MP concentrations compared to the underlying surface ocean?
2. Does MP transport by sea ice affect the MP concentrations globally?
3. Does variability in ocean MP concentrations affect the MP concentrations in sea ice?

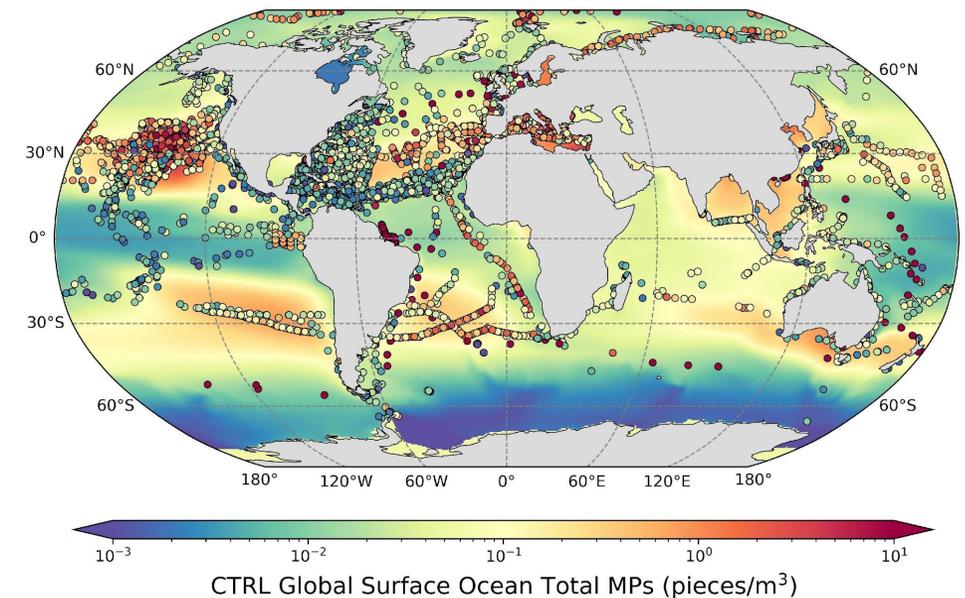
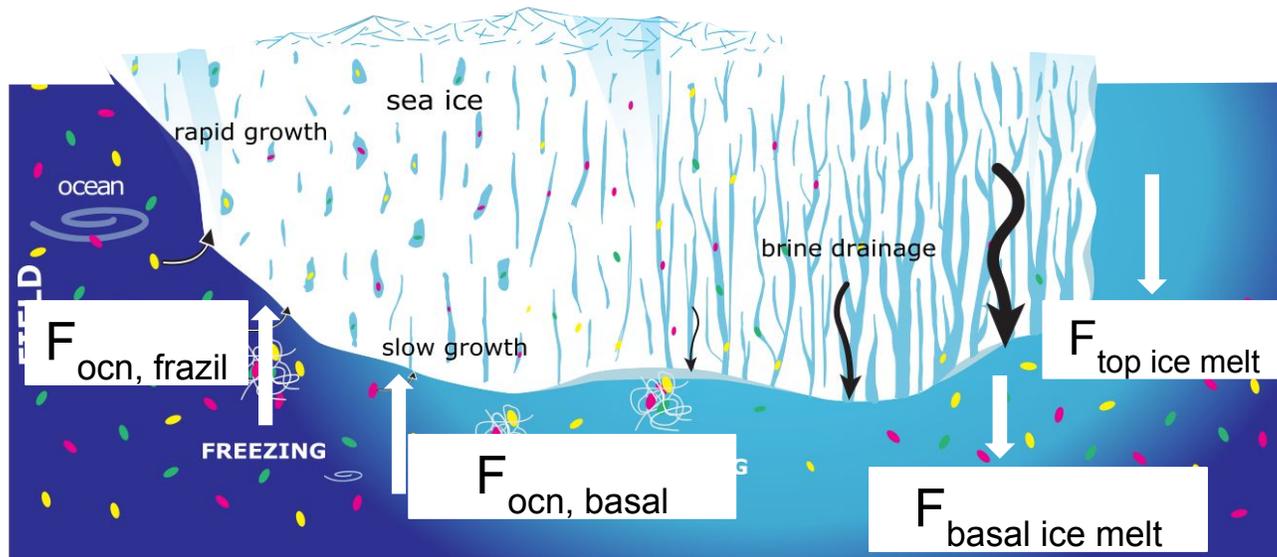
Modeling microplastics using CESM2

- MP tracers were added in the Community Earth System Model version 2 (CESM2): **neutrally buoyant (NB)** and **positively buoyant (PB)** MPs. Buoyancy only affects the tracer movement in the ocean.
- Using coastal plastic waste input data scaled by the total population density within 200 km of the sea.
- Negatively buoyant MP not included as these particles rapidly sink below the surface layers and therefore largely do not reach the Arctic

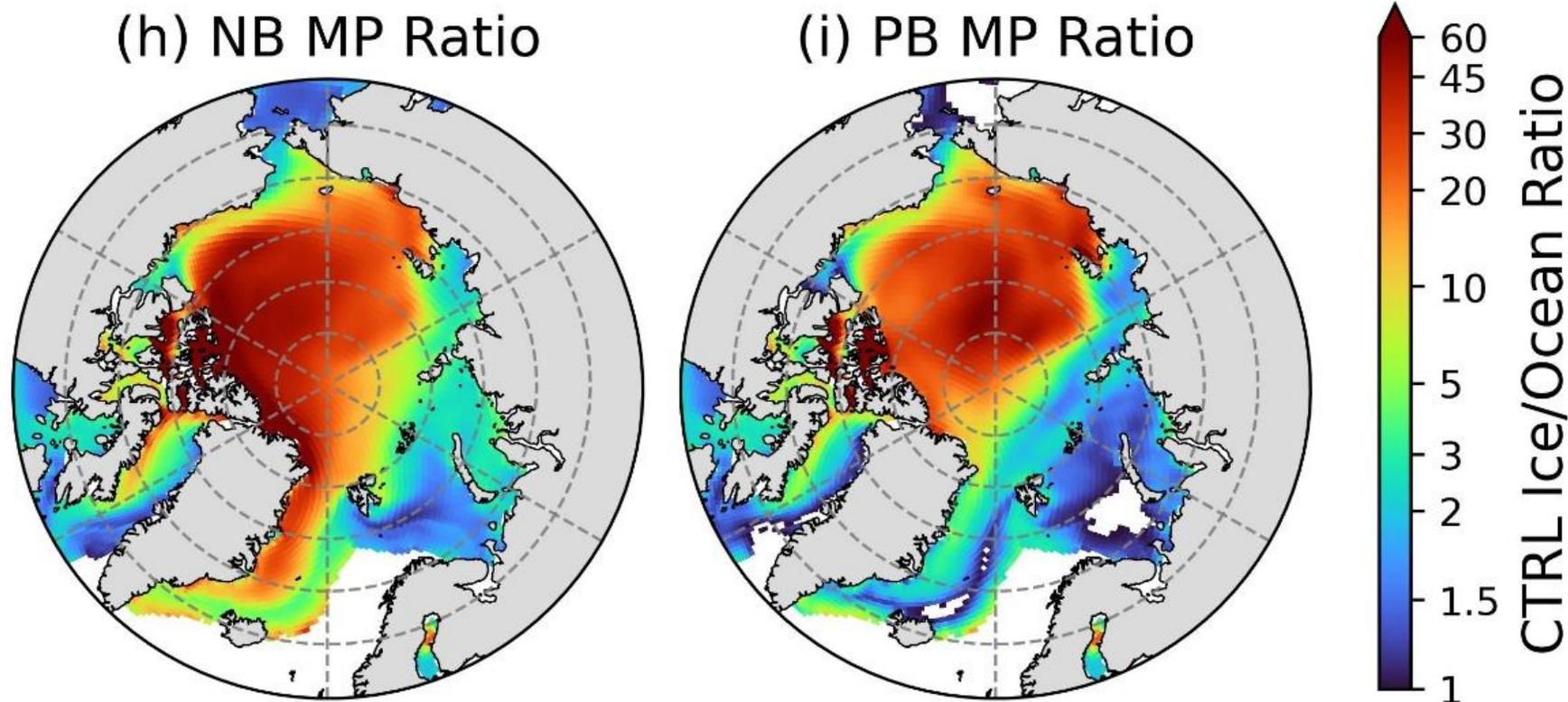


Modeling microplastics using CESM2

- Three factors: uptake factors for MPs during frazil ice and basal ice growth, and release factor during top ice melt, assuming all MPs lost during basal ice melt.
- For the control experiment (CTRL), MP uptake factors are set to 1 and release factor set to 0.
- The simulated total MP concentrations in CTRL (sum of NB and PB MPs) show overall good agreement with ocean observations globally.



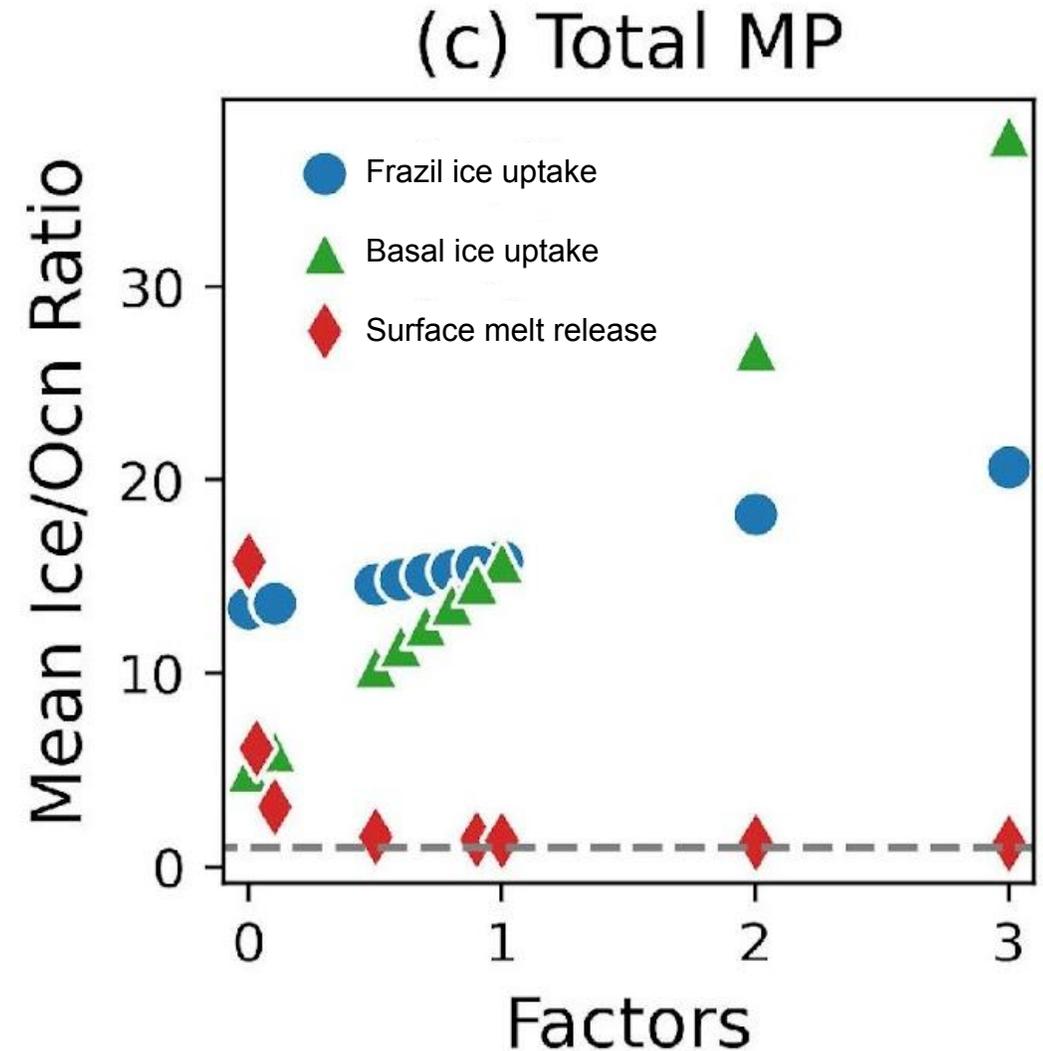
Q1: Enhanced sea ice MP concentrations



- The model can reproduce higher MPs concentrations in sea ice than in the ocean, consistent with observations.

Q1: Role of sea ice formation and ice melt

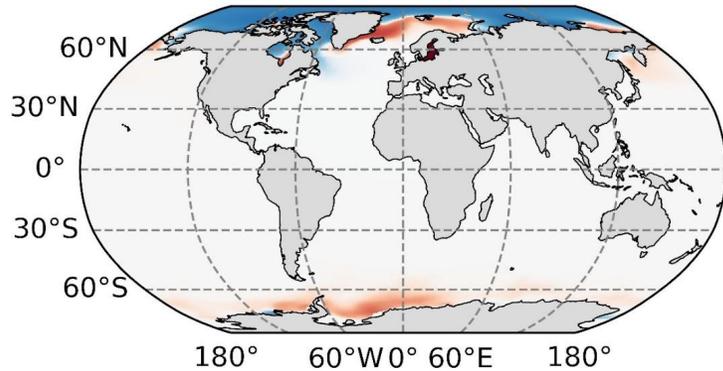
- Increasing basal ice uptake leads to enhanced ratio by a factor of 5.
- Increasing frazil ice uptake increases the ratio by ~50%.
- Nonlinear response to changes in the surface melt release factor
- **Higher uptakes is not what causes the increased MP concentration in sea ice compared to the surface ocean.**



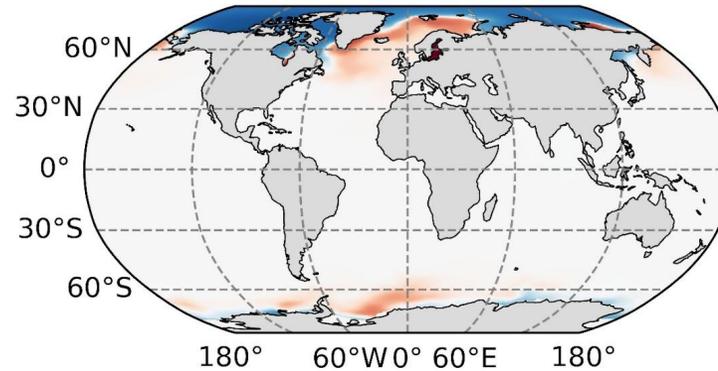
Q2: How does MP transport by sea ice affect MPs in global oceans?

Case Name	Descriptions
No Uptake	No MPs trapped into sea ice

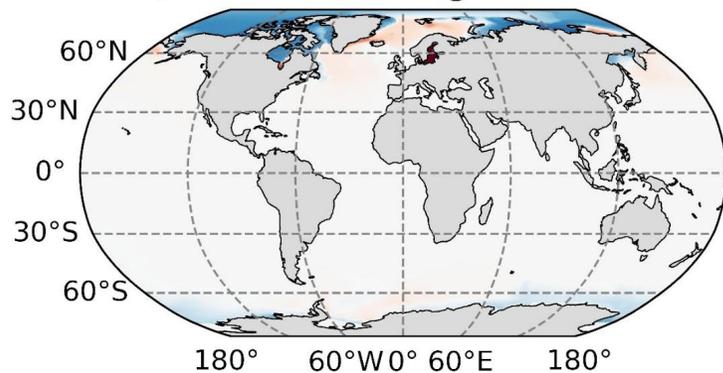
(a) Upper Ocean NB MP



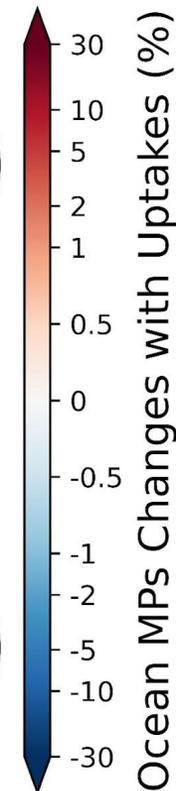
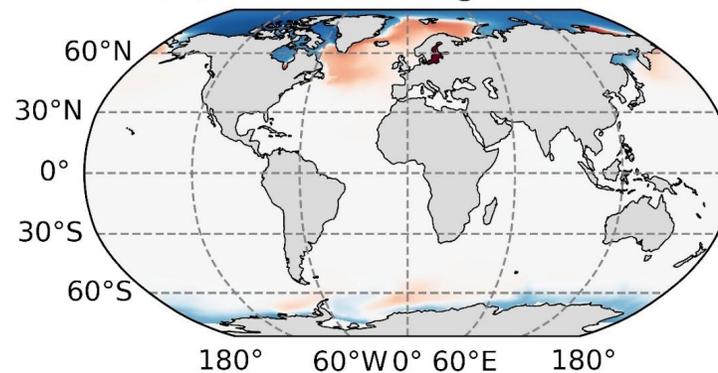
(b) Upper Ocean PB MP



(c) Vertical Integral NB MP



(d) Vertical Integral PB MP

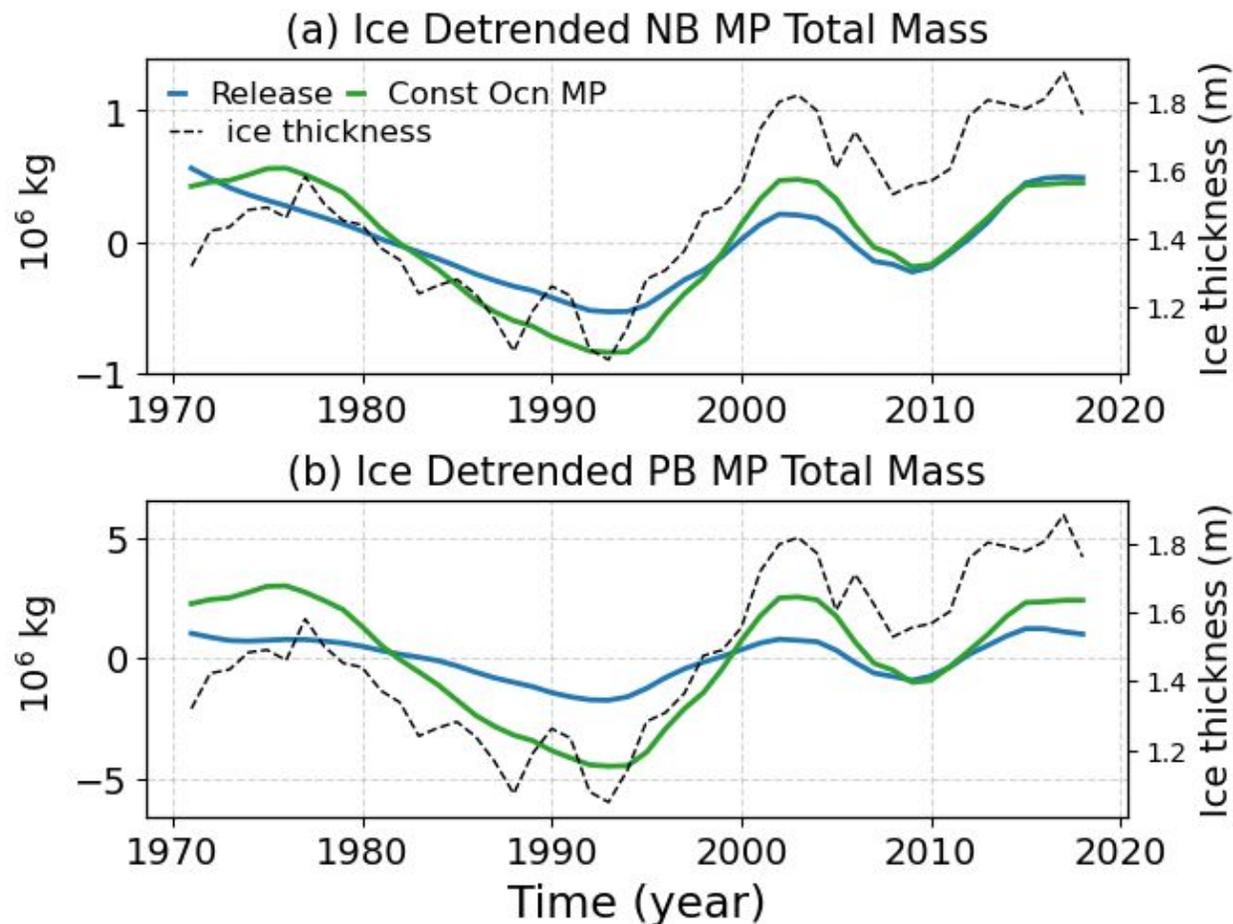


- 30% decrease in MPs concentrations in the Arctic Ocean compared to No Uptake case, driven by uptaking MPs into sea ice
- Small (~1%) increase in MPs in the North Atlantic, driven by differences in MP transport pathways between sea ice and the ocean

Q3: How does ocean distribution of MPs relate to MPs in Arctic ice?

Case Name	Descriptions
Release	MPs trapped into sea ice during growth and released through basal and top melt
Const Ocn MP	Ocean MPs are spatially and temporally constant, otherwise like Release

- Annual mean MP mass from 1970-2017 are detrended and smoothed using 5-year block averages.
- Similar temporal variability in two cases, with slightly larger amplitudes for Const Ocn MP case.
- Variability in sea ice MP mass is strongly related with sea ice thickness.



Summary

- The model can reproduce higher MPs concentrations in sea ice than in the ocean, consistent with observations.
- Sea ice melt and congelation ice formation dominate MP redistribution between the ocean and sea ice.
- The inclusion of MP transport in sea ice was found to be only relevant within ice covered regions, with minimal impact on MP distributions in lower latitude oceans.
- The enhanced sea ice MP concentrations can not be simply explained by the higher uptake factors or the variability in ocean microplastics
- Also analyzed seasonal and interannual variability of MPs in sea ice and ocean, please feel free to reach out (Li et al, in prep)!

