

Towards a better understanding of high latitudes in the climate system

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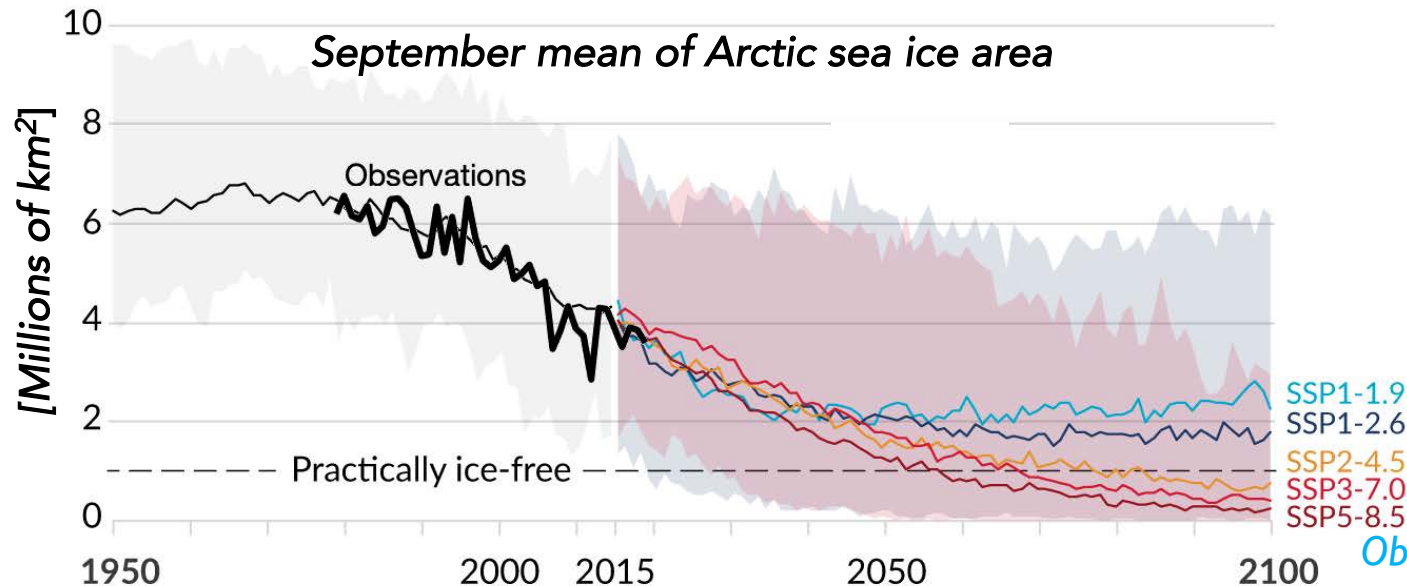
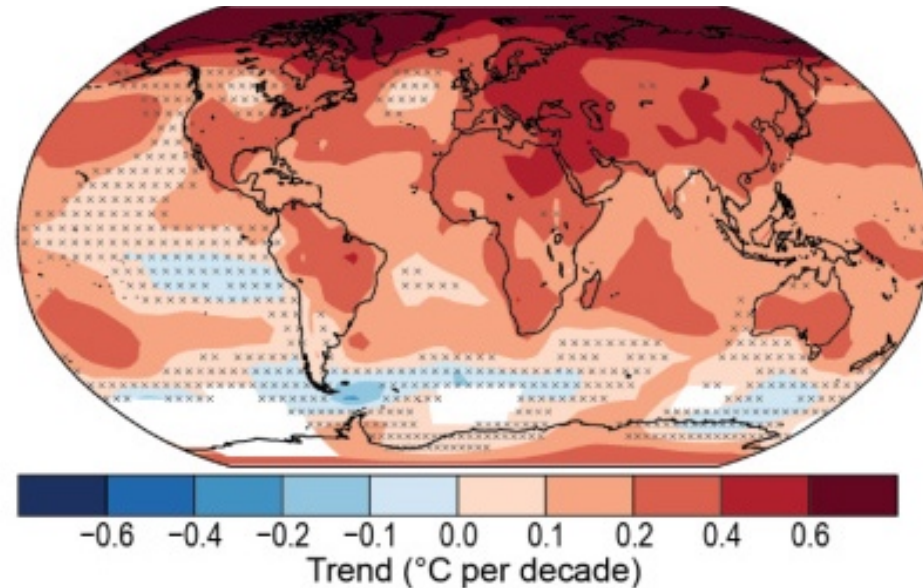
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The Arctic in transformation

- The polar regions, and the Arctic in particular, are undergoing some of the fastest changes on the planet in response to climate change
- All the components of the Arctic are affected (ocean, atmosphere, cryosphere, land), with large impacts on the ecosystems

SAT (Annual mean) – 1981-2020



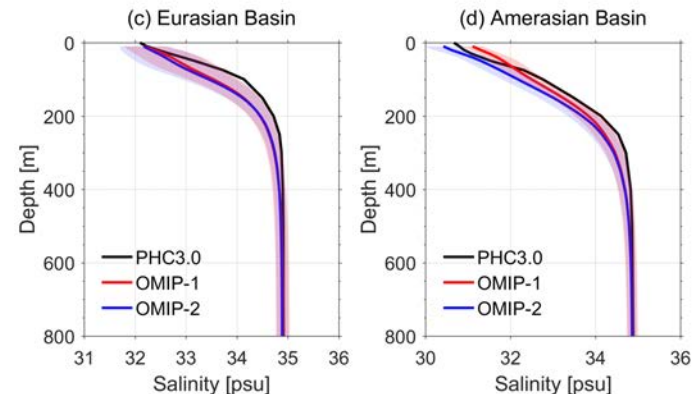
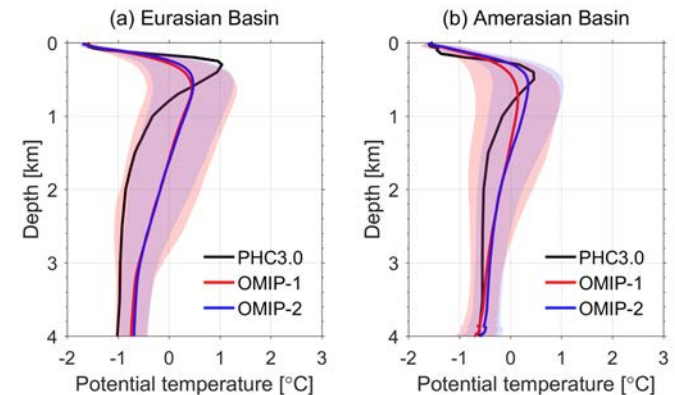
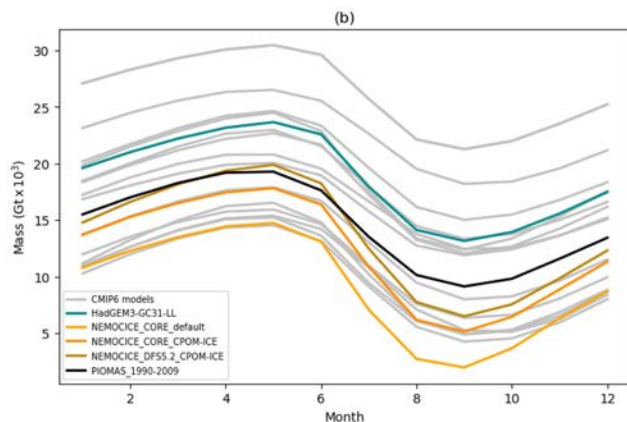
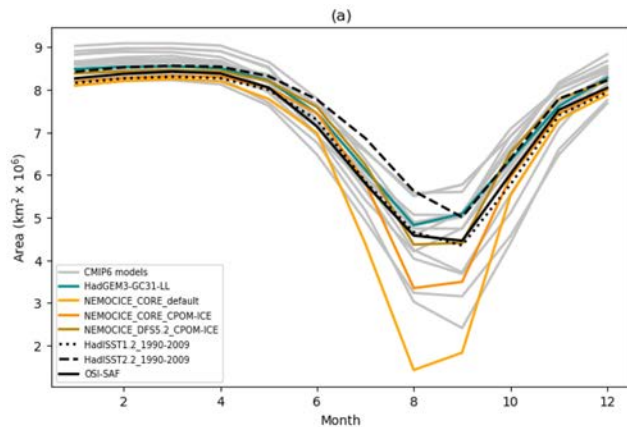
Observations: NSIDC, MetOffice
IPCC (2021)

The Arctic in transformation

Large uncertainty on future changes in the Arctic remains, that translates into uncertainty on the climatic, economic, political, and social impacts

This is due to:

- (a) a lack of understanding of the key processes setting up the physical ocean and sea ice conditions in the Arctic
- (b) a poor representation of these key processes in state-of-the-art Earth System Models



Data from CMIP6 & OMIP1/2, Keen et al. (2021), Shu et al. (2023)

Ocean-sea ice interaction at small scales

Part of these missing processes corresponds to **ocean-sea ice interactions occurring at small scales**, particularly in the Marginal Ice Zone

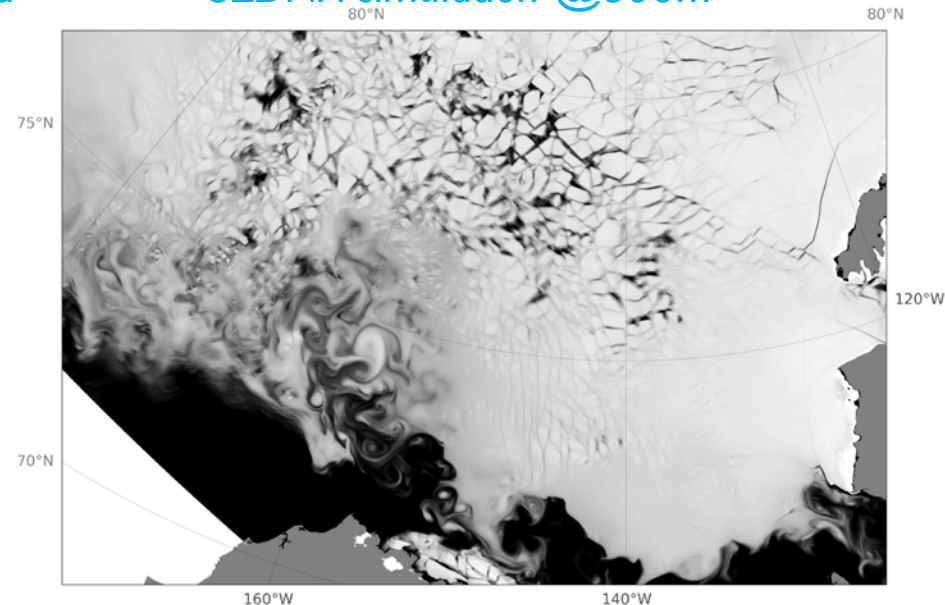
3 examples in the following:

- Eddy - sea ice interactions
- Sea ice leads and break up signature on the mixed layer dynamics
- Signature of the sea ice melt on the surface layer

Satellite observations (Terra-MODIS) - Beaufort Sea

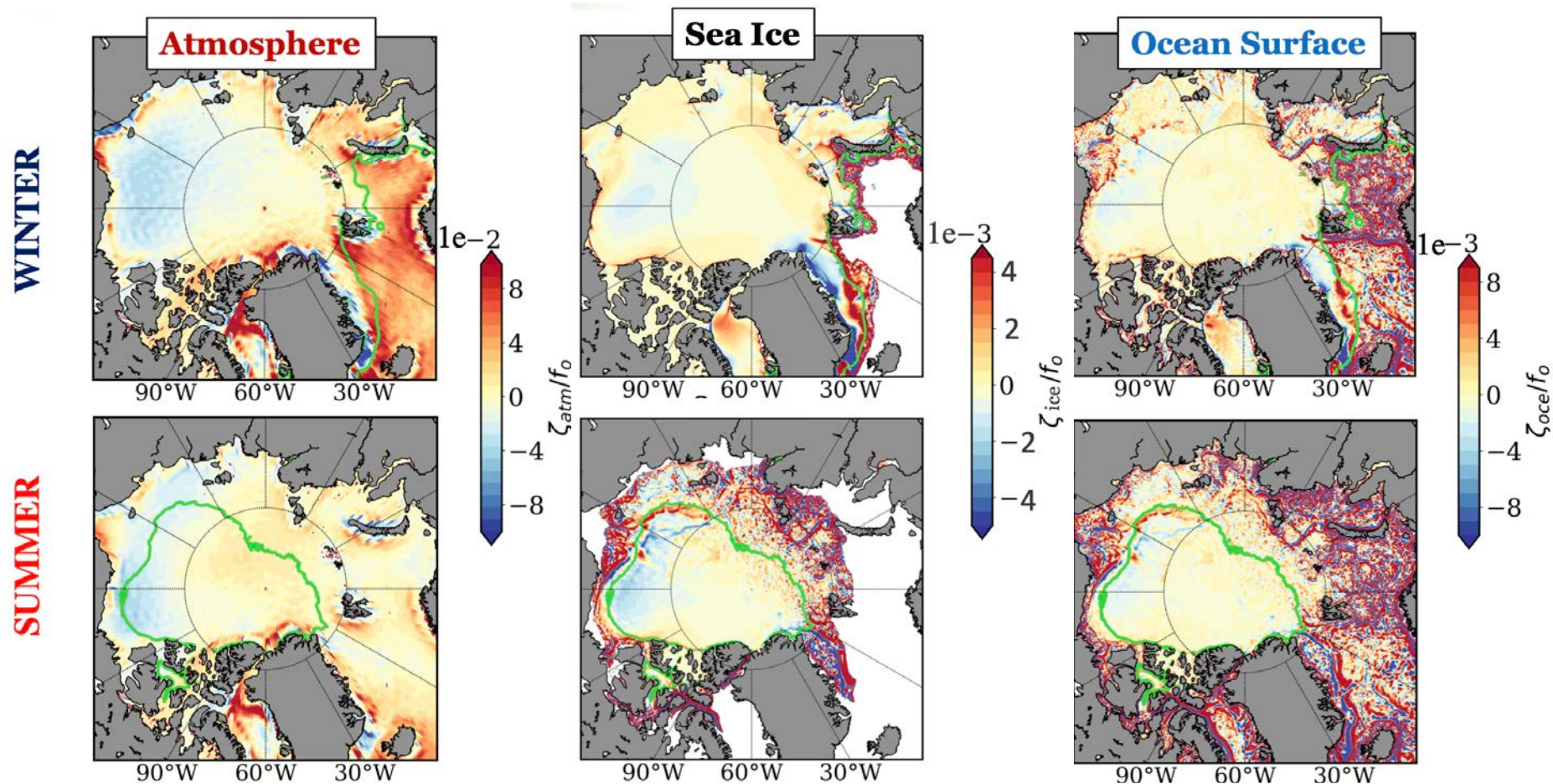


SEDNA simulation @800m



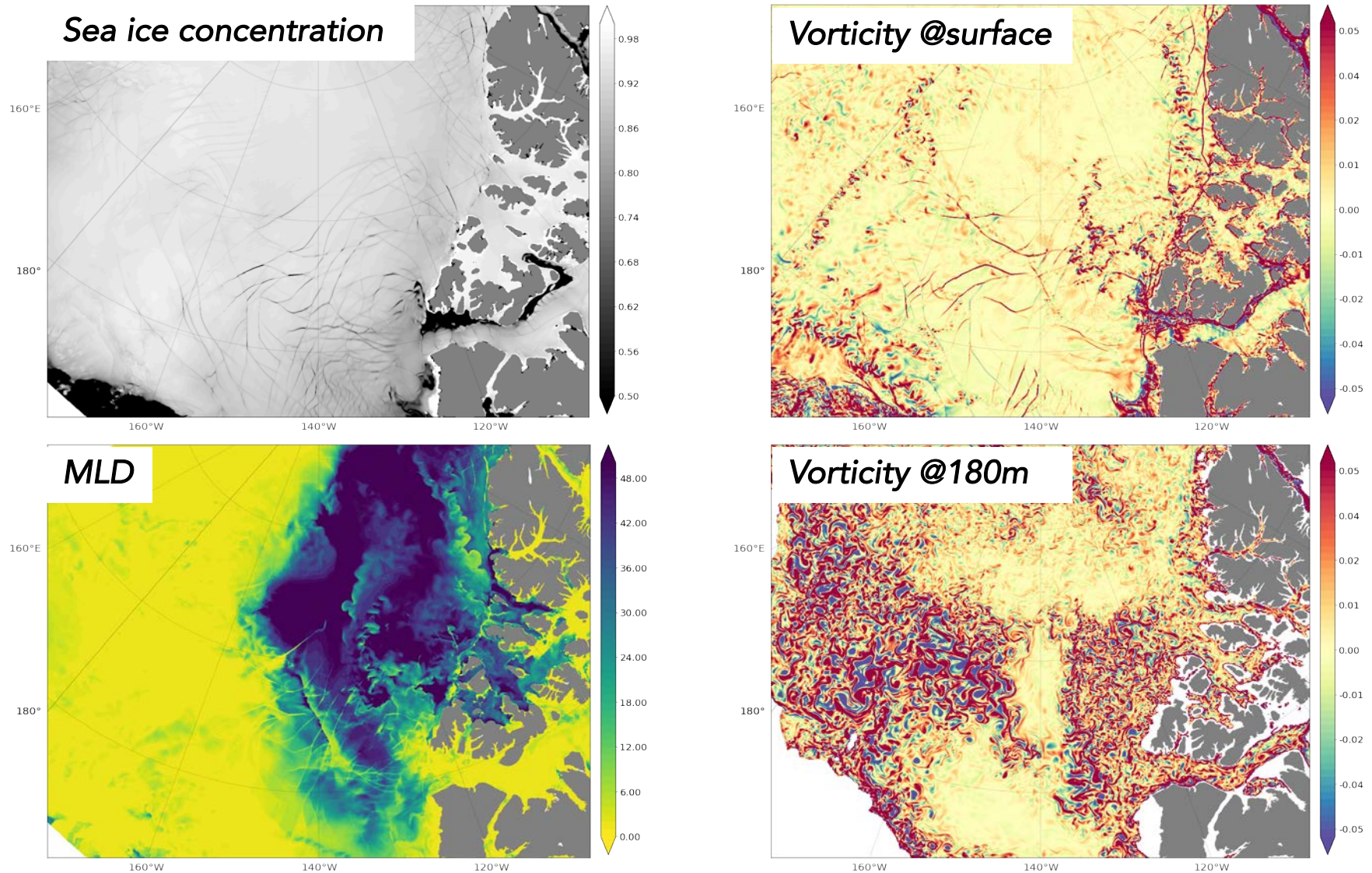
Ocean-sea ice interaction at small scales – mesoscale eddies

- At the pan-Arctic scale, sea ice vorticity carries the signature of the atmosphere and the **ocean mesoscale eddies** (specially in summer, when concentration are below 80% and the rheology gets negligible)
- With possible impacts on the evolution of the sea ice conditions



Ocean-sea ice interaction at small scales – *mixed layer dynamics*

In the mixed layer, sea ice leads promote heterogeneity, but sea ice friction dissipates turbulence

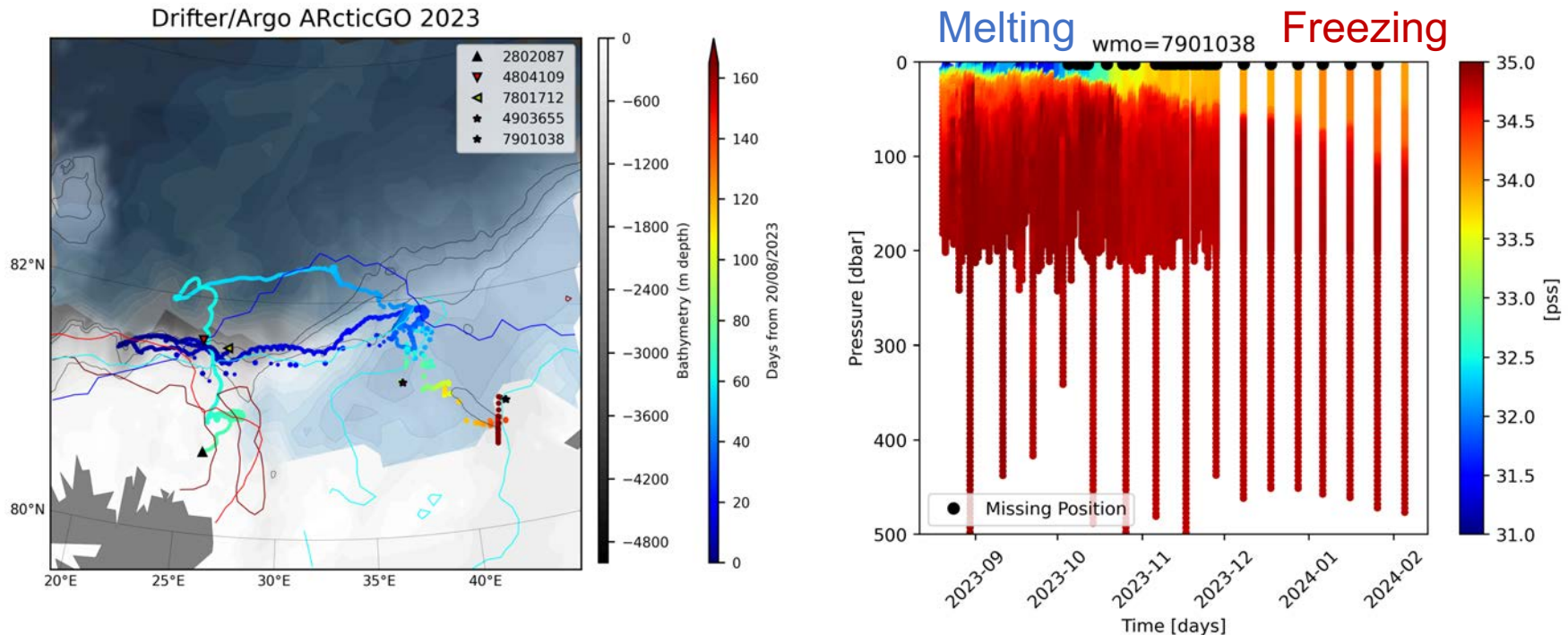


Snapshot for June 23rd 2003, data from SEDNA @ 800m resolution

Ocean-sea ice interaction at small scales – sea ice melt in the MIZ

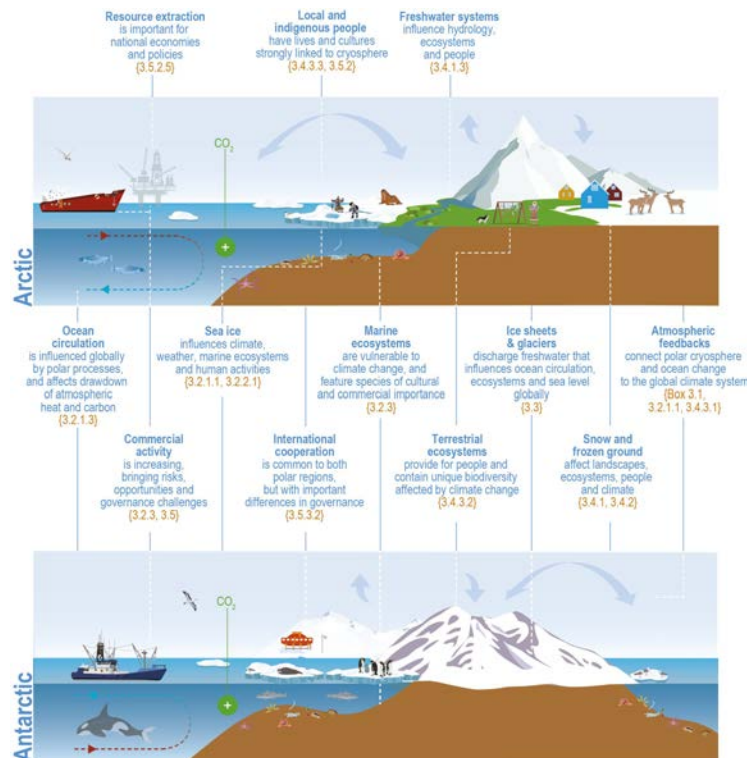
In nature, the signature of sea ice melt is often a thin (less than 10m) surface layer of freshwater ... but it remains poorly observed (and not captured by models!)

- **Observational effort in the MIZ north of Svalbard:** Deployments of drifters + 10 Argo floats (collaboration with the Polar Argo Mission to adapt the floats) + improvement of the retrieval algorithms for SSS (eg SMOS) and SSH (eg SWOT) in the MIZ.
- Obj: Disentangle the different processes at play (eddies, tides, change of stratification. ...)



Synergies between the Arctic and Antarctic science communities

- Understanding the changes in the polar regions requires to consider all the components altogether (ocean, atmosphere, sea ice, ice sheet)
 - There is also a growing recognition that similar processes are at play in both poles, despite an historical disconnection between the communities
- > A pledge of the French polar science community for a unified polar program
- > Efforts (incl. as part of VCRP) to bring the bipolar community together



ICTP International Centre for Theoretical Physics

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School and Workshop on Polar Climates: Theoretical, Observational and Modelling Advances

22 - 31 July 2024 Trieste, Italy

Logos of participating organizations: CLIC, IASC, SCOR, CLIMAP, and others.

