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Characterizing First Year and Multi Year Sea Ice using NESOSIM

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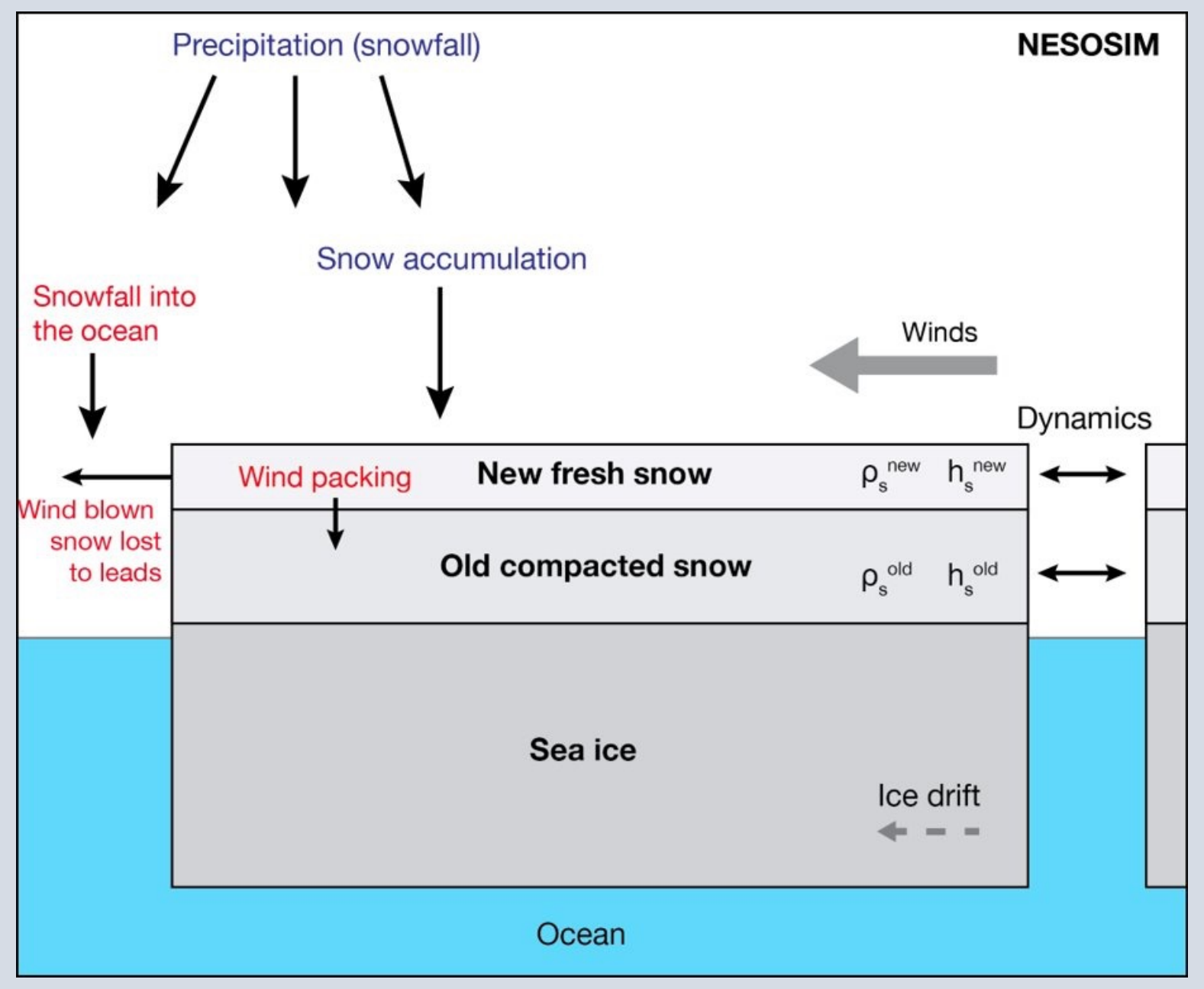
Introduction and Objectives

- Arctic sea ice regulates planetary albedo, and its annual melt-freeze cycles affect the climate across the polar region
- The last 30 years has seen a regime shift from multi-year to first-year dominated sea ice
- First-year ice (FYI) and multi-year ice (MYI) often differ in some physical properties, affecting their melt patterns and resilience to temperature change
- Snow falling on sea ice can affect the ice's growth, its resistance to melt, and its albedo, but is difficult to observe, so models are used
- Goal: characterize patterns in snow on sea ice across regions and ice ages

Data, Methods

- NASA Eulerian Snow on Sea Ice Model (NESOSIM) freeze season (September to April) daily output at 100km resolution driven by ERA5 snowfall input
- Weekly sea ice age data from the National Snow and Ice Data Centre (NSIDC) regridded from EASE-grid to 100 km resolution NESOSIM grid
- NESOSIM regional mask



NESOSIM is a two-layer snow on sea ice model. Snow falls onto the upper layer, and is transferred to the lower layer through densification by winds (wind pack). Snow can also be lost from the upper layer when blown off into the air (atmosphere loss) or open water (lead loss).

Fig 1: The snow layers and mechanisms in NESOSIM (reproduced from Petty et al., 2018).

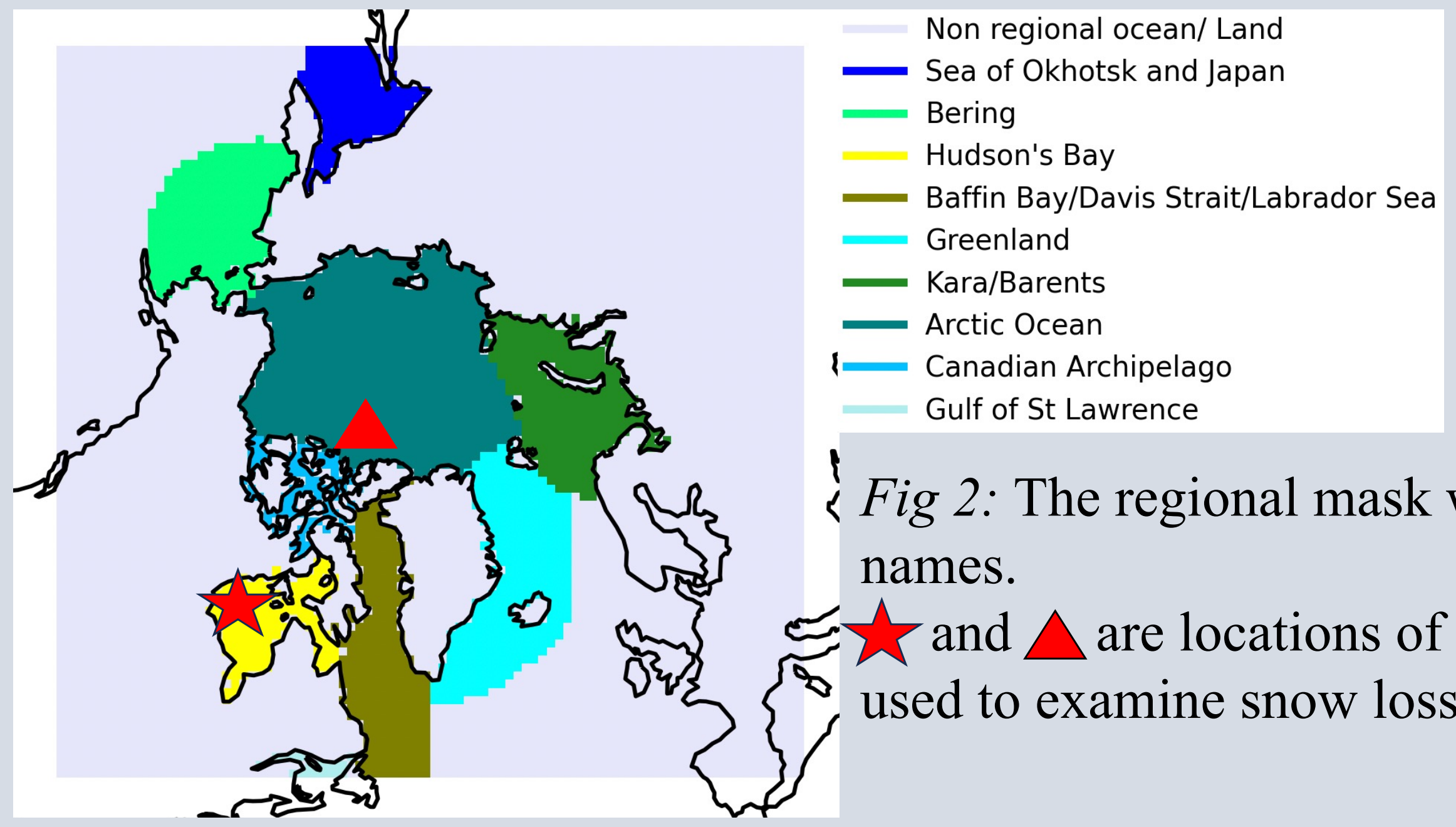


Fig 2: The regional mask with region names.
★ and ▲ are locations of grid squares used to examine snow loss processes.

Results

Snow Water Equivalent

- While the snow water equivalent (SWE) is increasing on both FYI and MYI across the Arctic basin over one freeze season, the rate of increase on MYI decreases while the rate on FYI increases. This pattern is consistent across decades.
- Snowfall maps suggest that this could be due to increasing snowfall in predominantly FYI regions (such as Baffin Bay/Davis Strait and Greenland) due to storm track activity later in freeze season

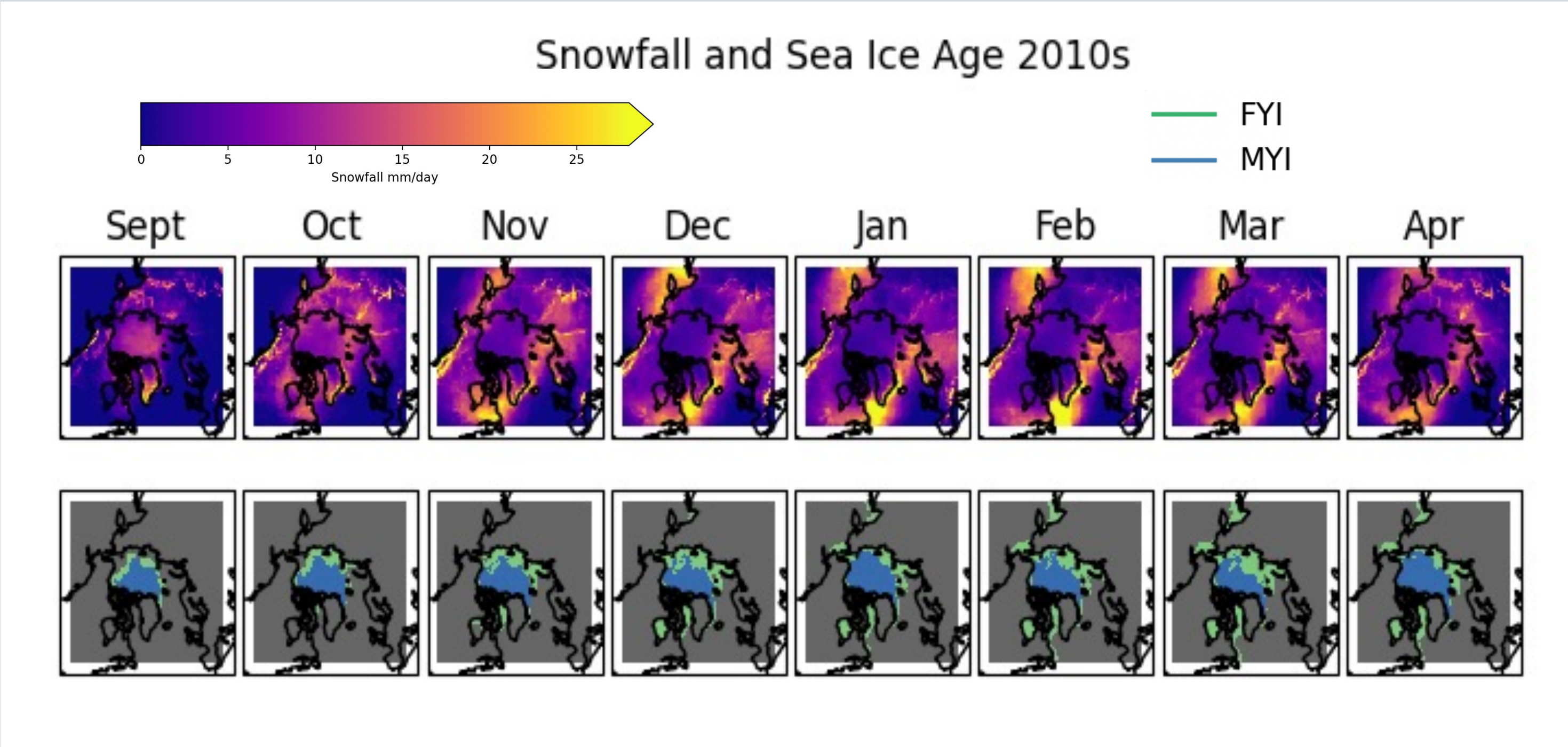


Fig 3: FYI and MYI in the Arctic basin and increase in snow from Pacific and Atlantic storm tracks through the freeze season.

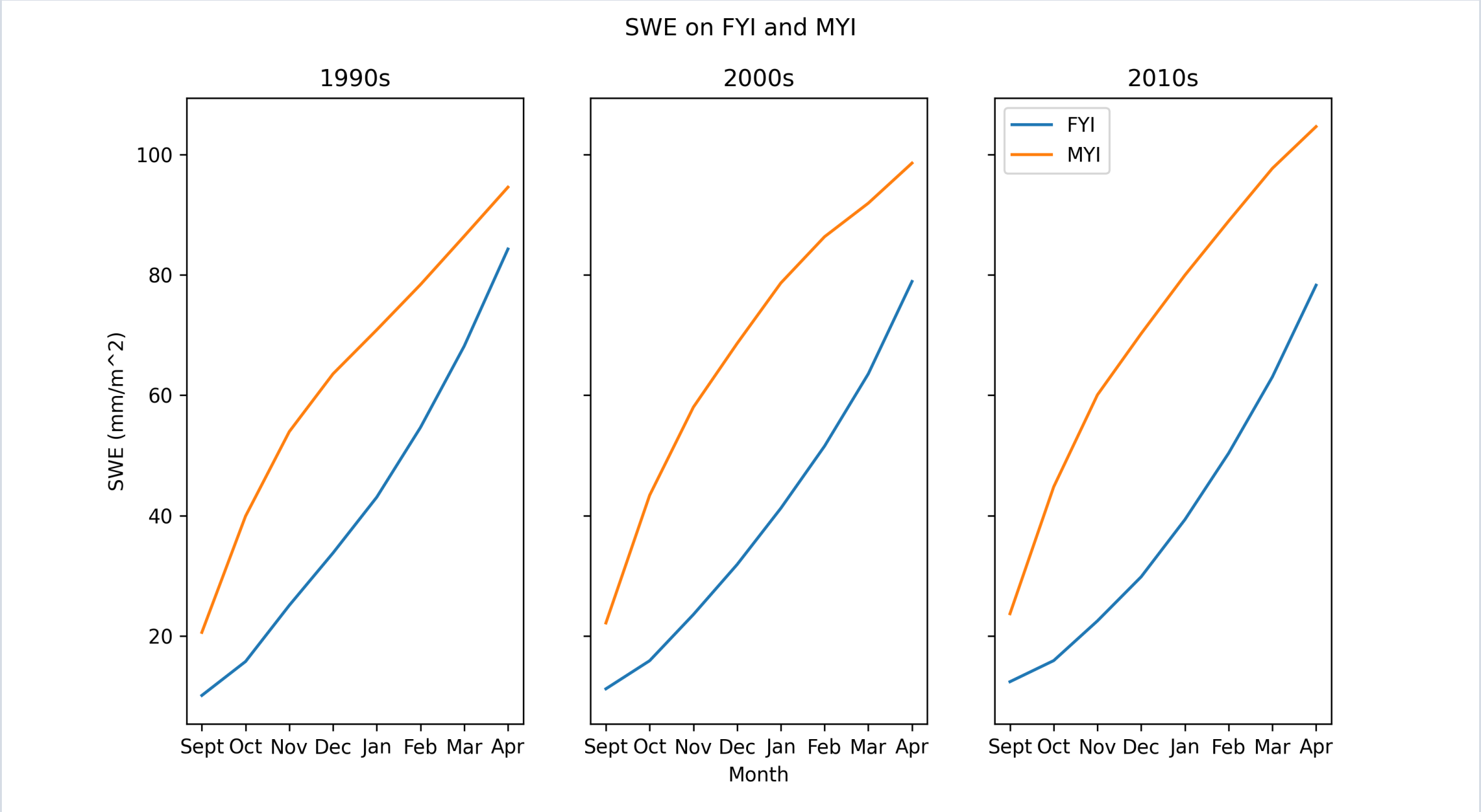


Fig 4: Decadal monthly climatologies of SWE on FYI and MYI.

Snow Layers

- In regions that consistently have MYI and FYI, the upper layer of snow has a consistent depth through the freeze season, due to densification process converting upper layer snow to lower layer snow, and snow loss processes.

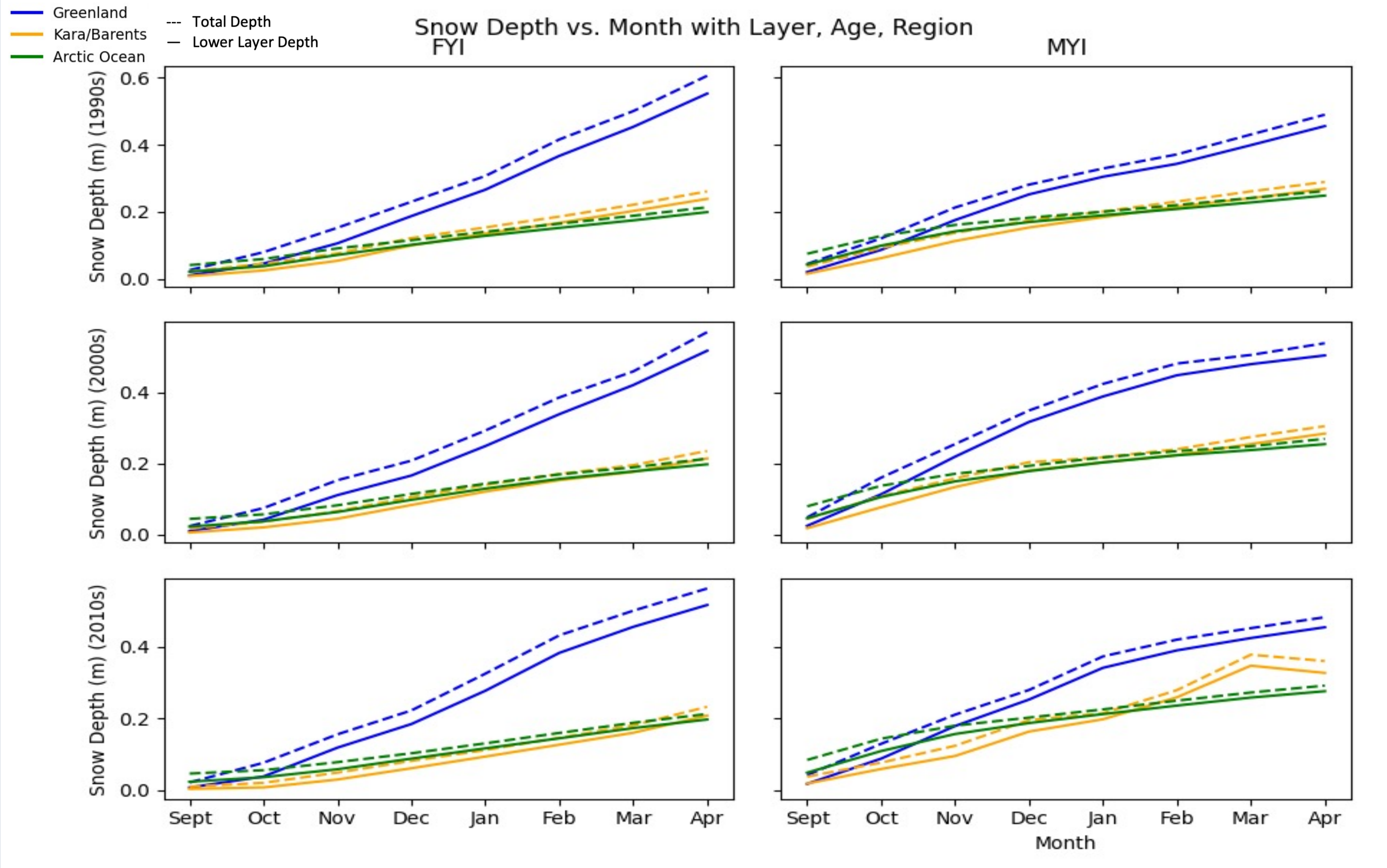


Fig 5: Decadal monthly snow depth climatologies on FYI and MYI.

Snow Loss Processes

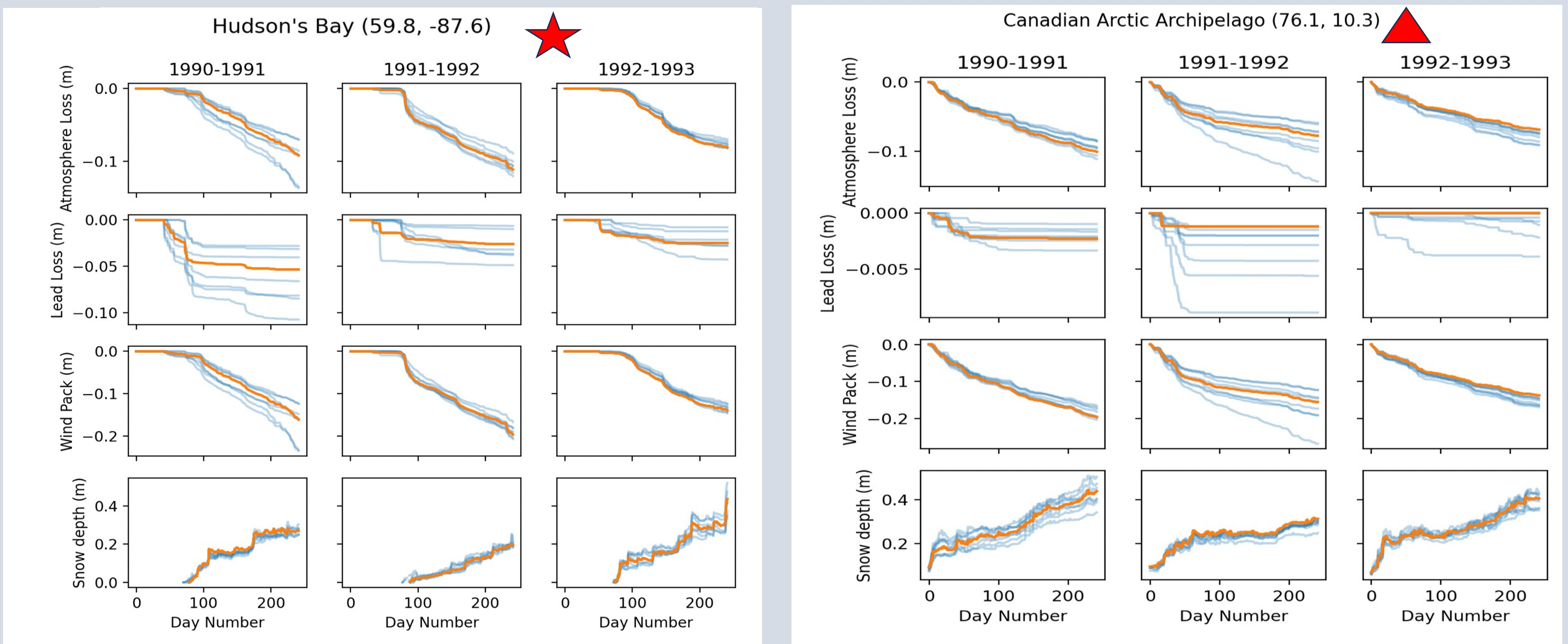


Fig 6, 7: Snow loss and densification processes for individual grid squares in the Hudson's Bay (FYI) and the Canadian Arctic Archipelago (MYI), as shown on the map. Adjacent grid squares are shown in blue. MYI regions such as the CAA seem to experience less lead loss than FYI regions since sea ice concentrations are higher as so there are fewer leads.

Discussion, Next Steps

- FYI's rate of snow accumulation accelerates as the season progresses due to increased storm track activity.
- Despite increased snowfall, the depth of the upper layer is consistent through the season. Snow layers may be better represented with a more complex density model.
- FYI experiences more lead loss than MYI, even when they have comparable atmospheric losses.
- Next steps: examine dependence of these results on uncertain model parameters and reanalysis snowfall input.

Marshall, S. (2012). *The Cryosphere*. Princeton University Press.
Petty, A. A., Webster, M., Boisvert, L., & Markus, T. (2018). The NASA eulerian snow on sea ice model (NESOSIM) v1.0: Initial model development and analysis. *Geoscientific Model Development*, *11*(11), 4577–4602. https://doi.org/10.5194/gmd-11-4577-2018
https://github.com/akpetty/NESOSIM