Unsupervised classification of the Antarctic marginal ice zone

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Antarctic marginal ice zone (MIZ)

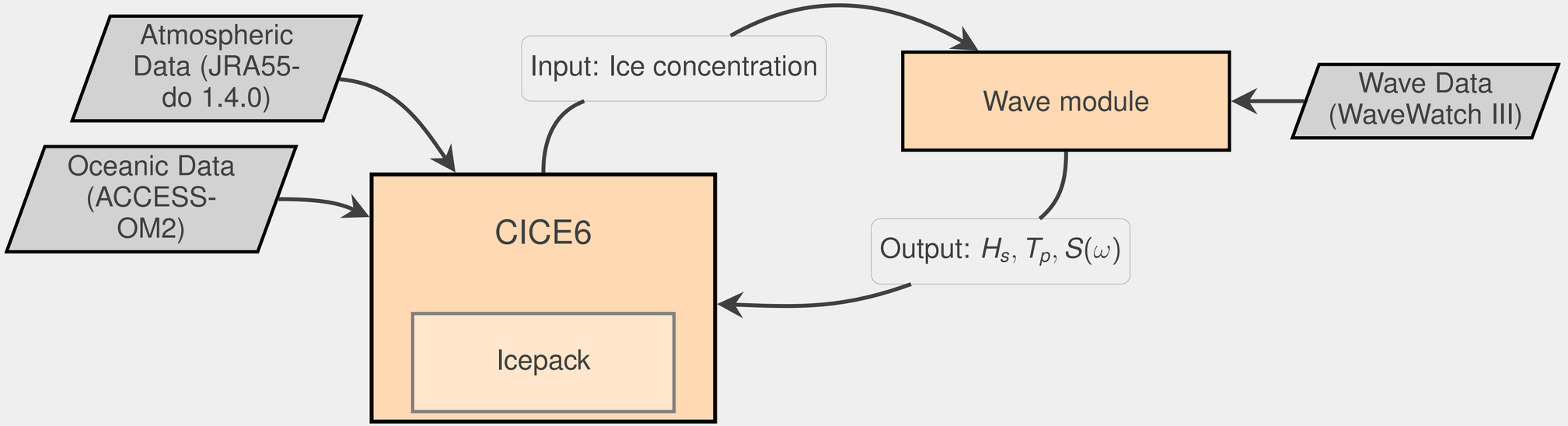
- The marginal ice zone is an interface between the open ocean and the consolidated inner pack
- Ocean surface waves can fracture ice floes 100s of km from the ice edge[1], and contribute to the formation of pancake ice in the marginal ice zone [2]

Credit: NASA/Nathan Kurtz.

[1] Kohout, A. *et al.*, Nature, (2014).
[2] Wadhams, P. *et al.*, JGR, (1987).

Marginal ice zone modelling

- We use CICE with a floe size distribution (CICE6-FSTD) to model Antarctic MIZ
- MIZ processes include: wave-breakup of floes, pancake ice formation (rather than nilas ice), lateral melt [3], and increased drift (and potentially free drift [4])



[3] Steele, M. *et al.*, JGR Oceans, (1992).
[4] Alberello, A. *et al.*, JGR Oceans, (2020).

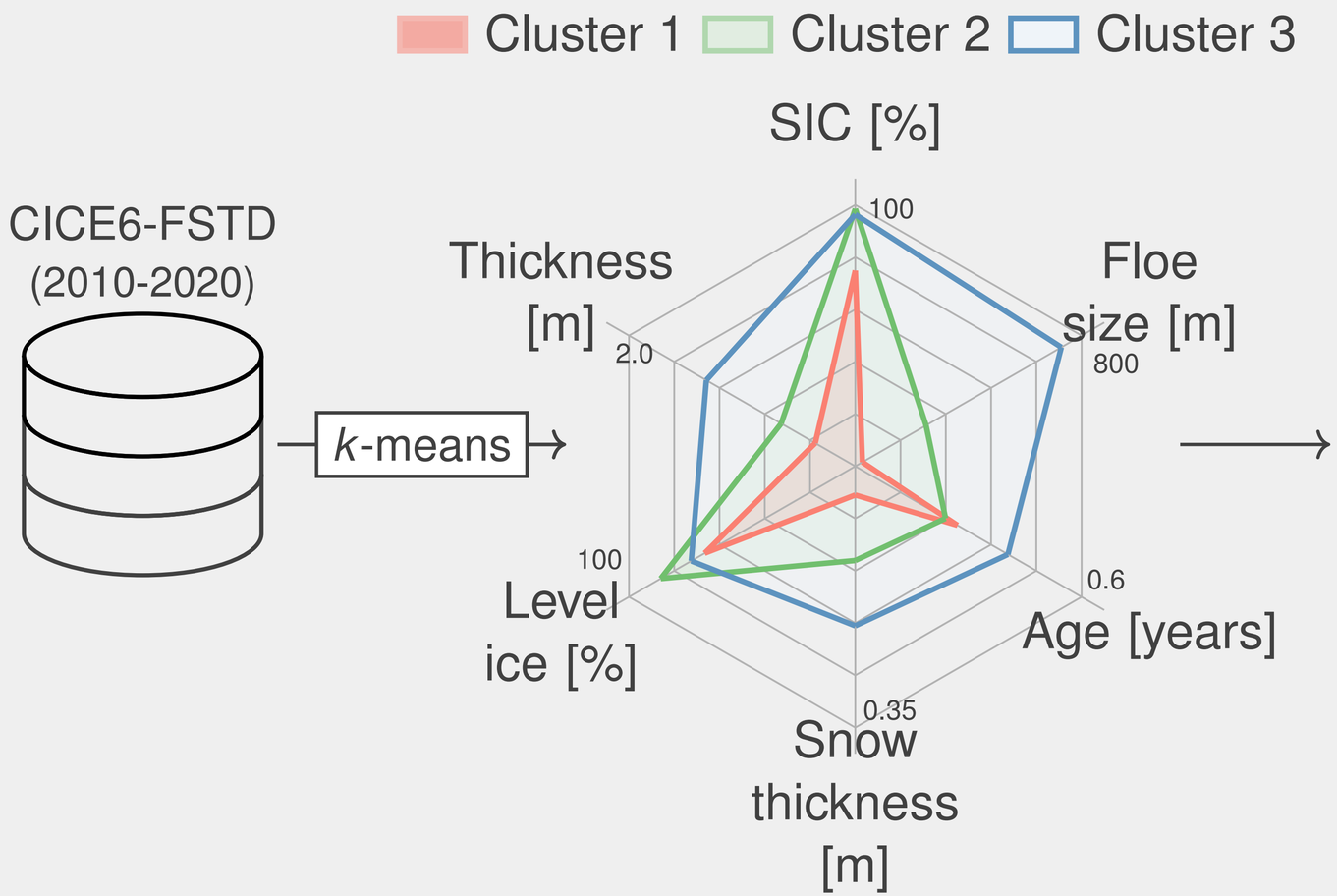
Motivation

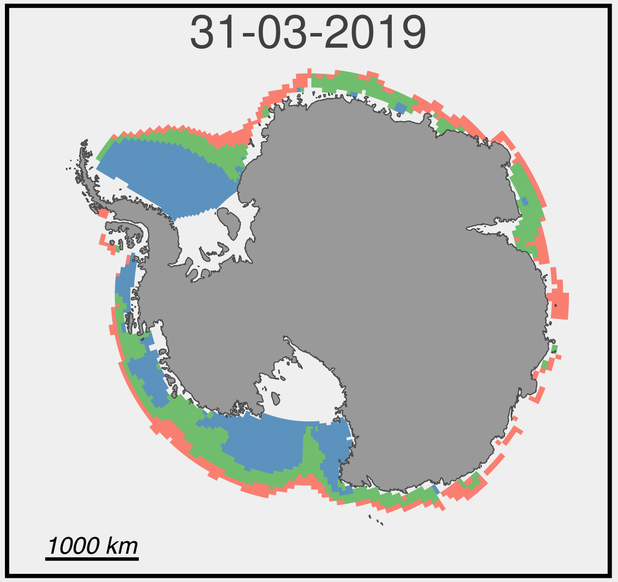
- Traditionally, a 15-80% sea ice concentration range has been used to quantify the marginal ice zone
- However, this is not appropriate for the winter Antarctic MIZ, where large waves and pancake floes have been measured with SIC $\approx$ 100% [5]
- *So, what should we use to quantify the MIZ?*

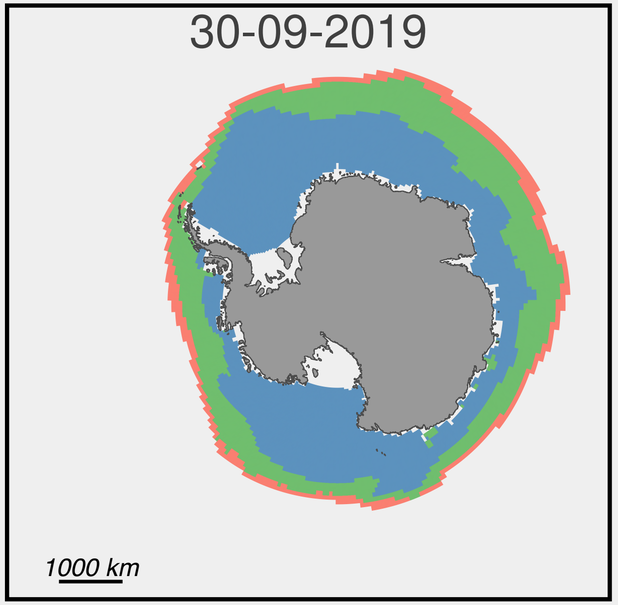
Credit: Sandra Zicus.

[5] Alberello, A. *et al.*, Nature Comms., (2022).

Unsupervised classification of sea ice data

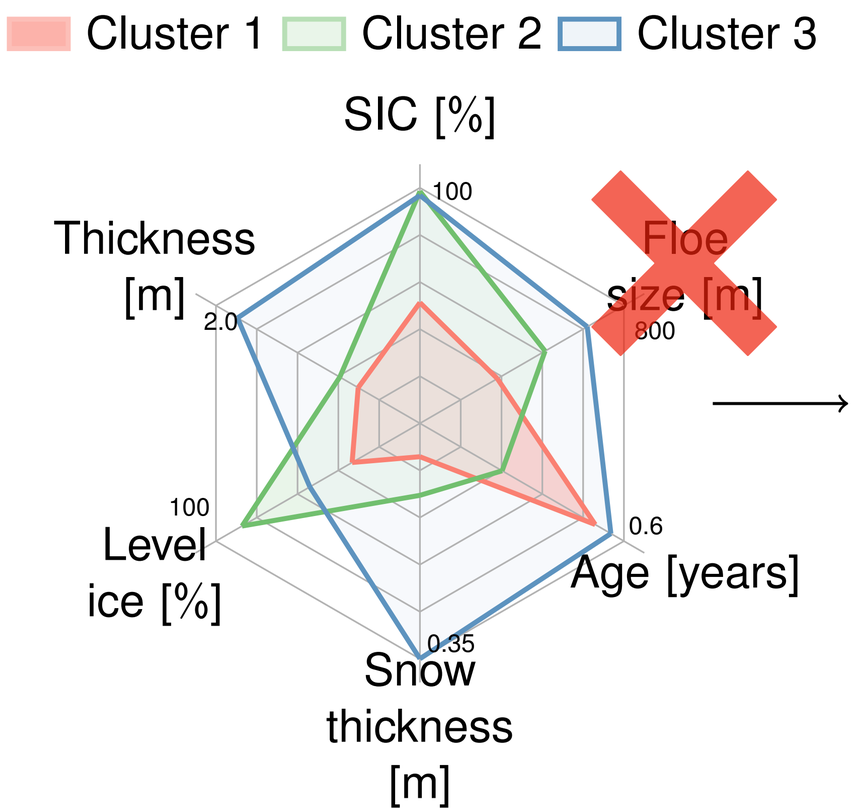


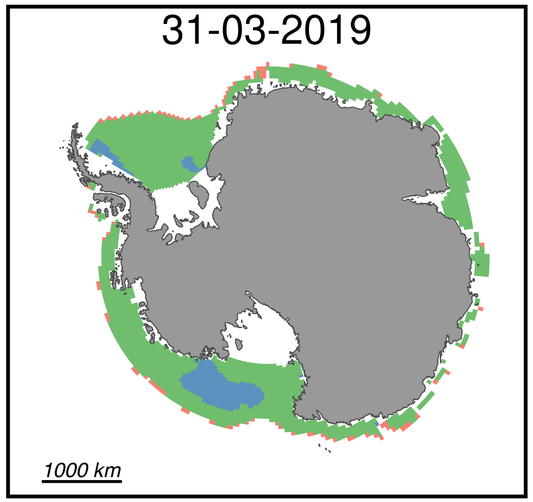


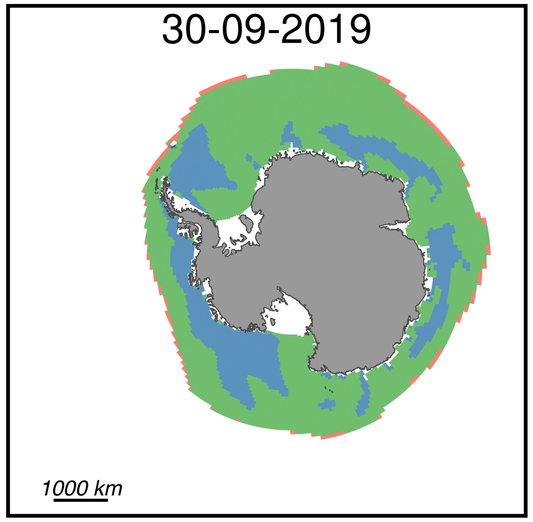


Unsupervised classification of sea ice data

CICE
(201

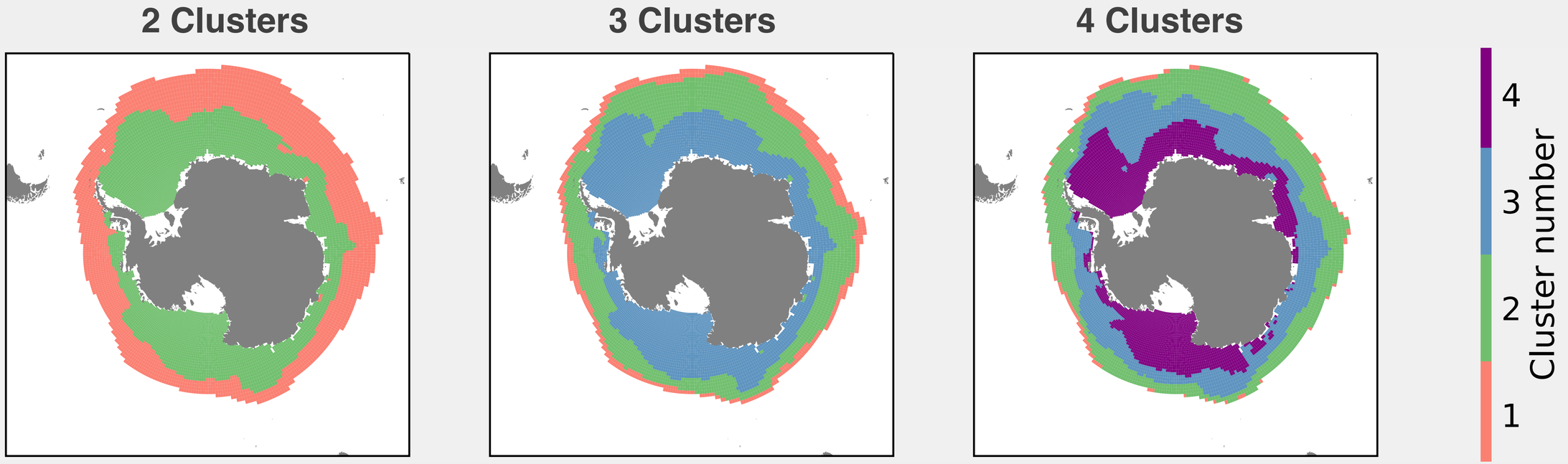




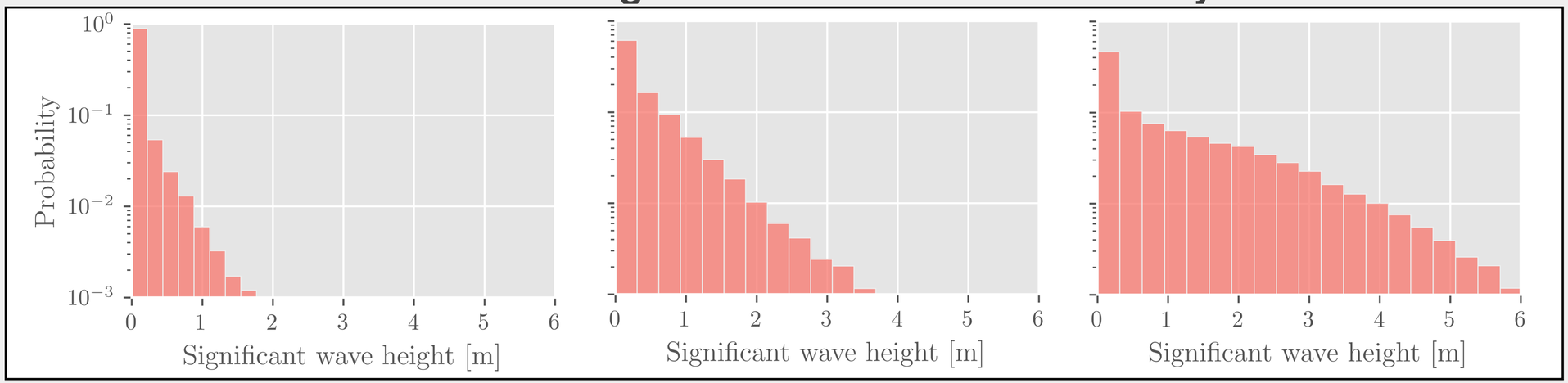


1000 km

Cluster number selection



Wave height at the interior MIZ boundary



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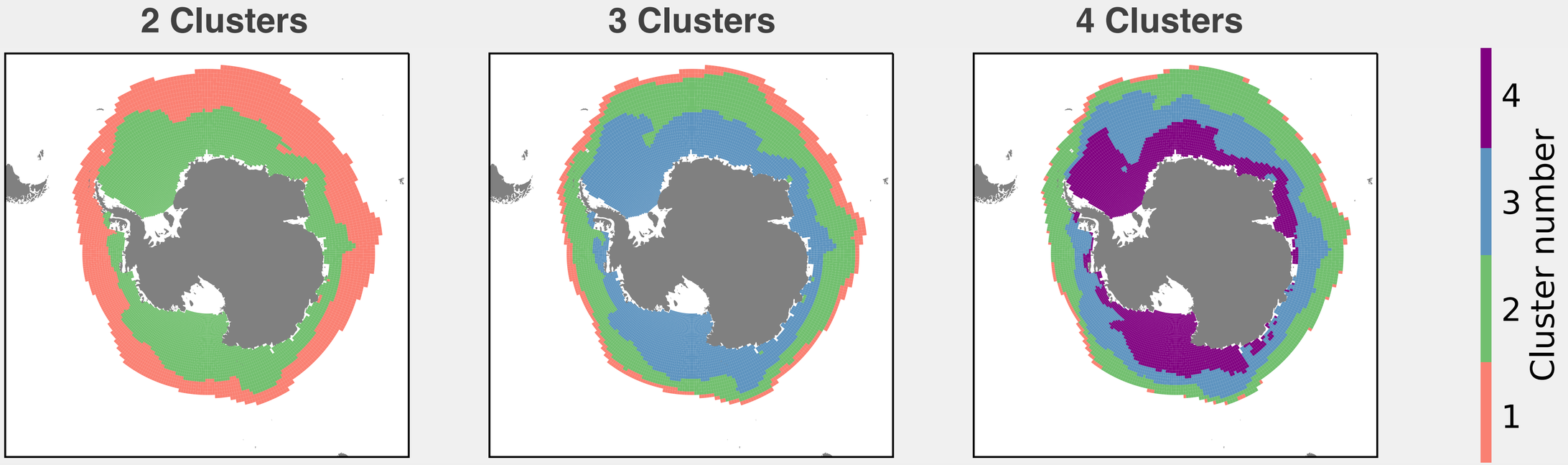

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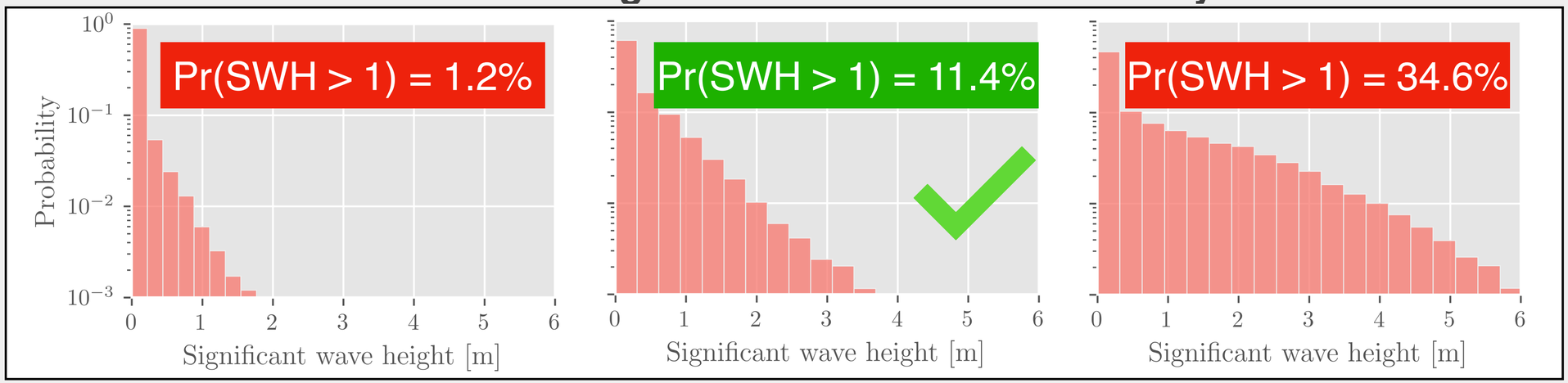
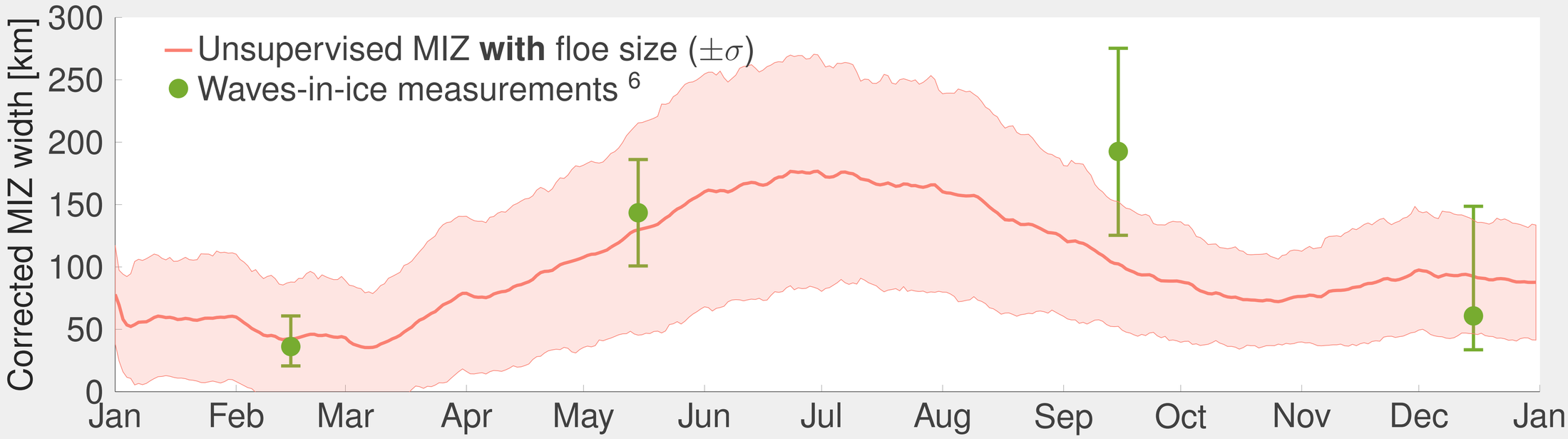


Marginal ice zone width

- The extent of the unsupervised MIZ is validated with altimetric observations of significant wave heights in sea ice [6]
- Floe size data allows us to capture the high-concentration wave affected regions



[6] Brouwer, J. *et al.*, The Cryosphere, (2022).

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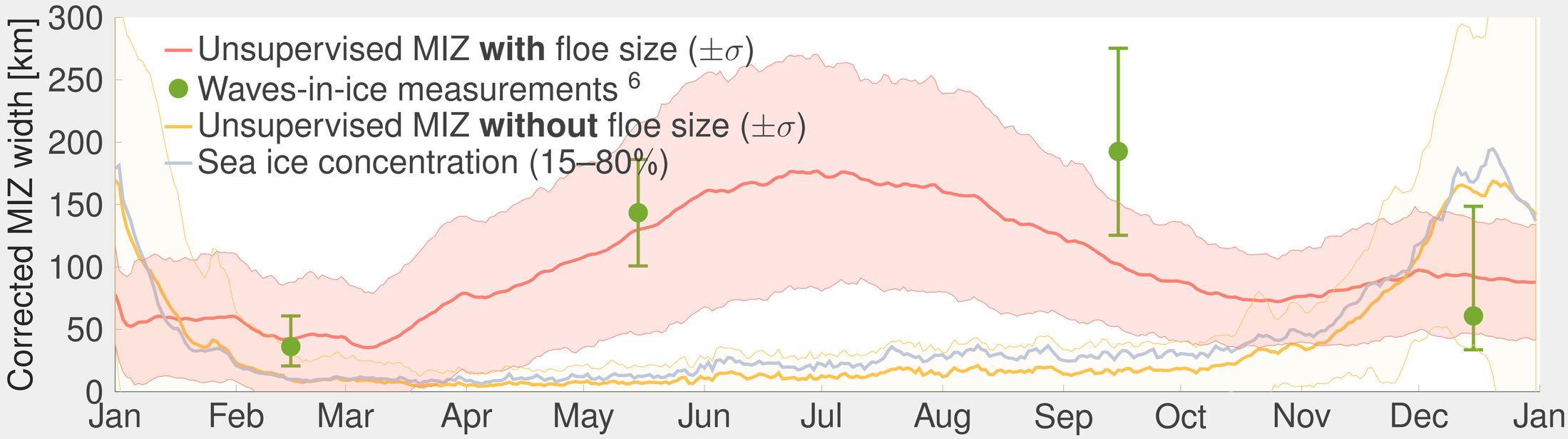
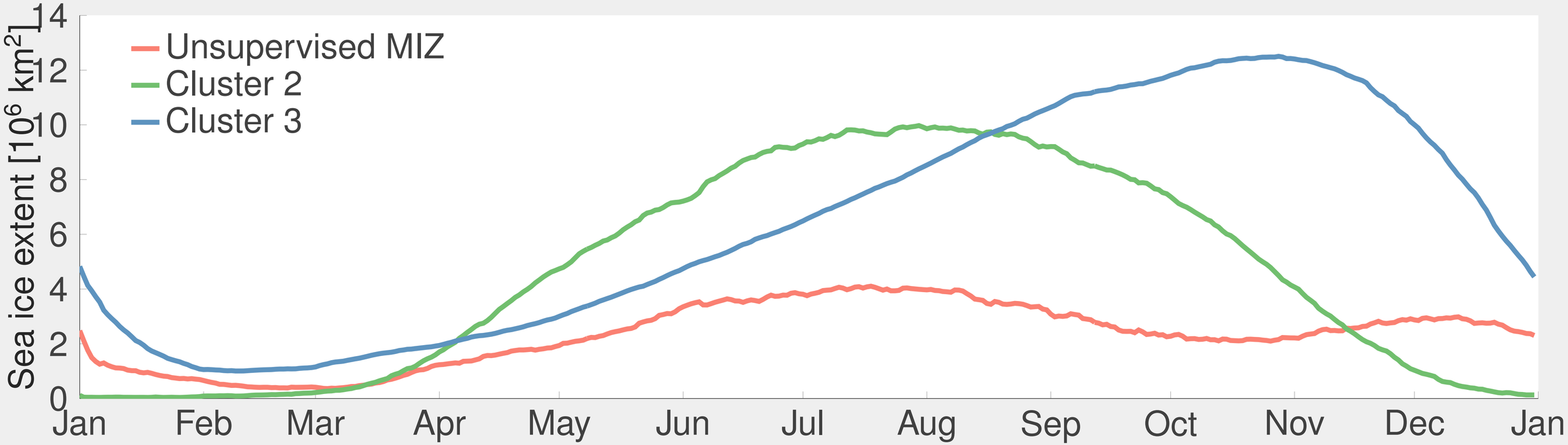


[6] Brouwer, J. *et al.*, The Cryosphere, (2022).

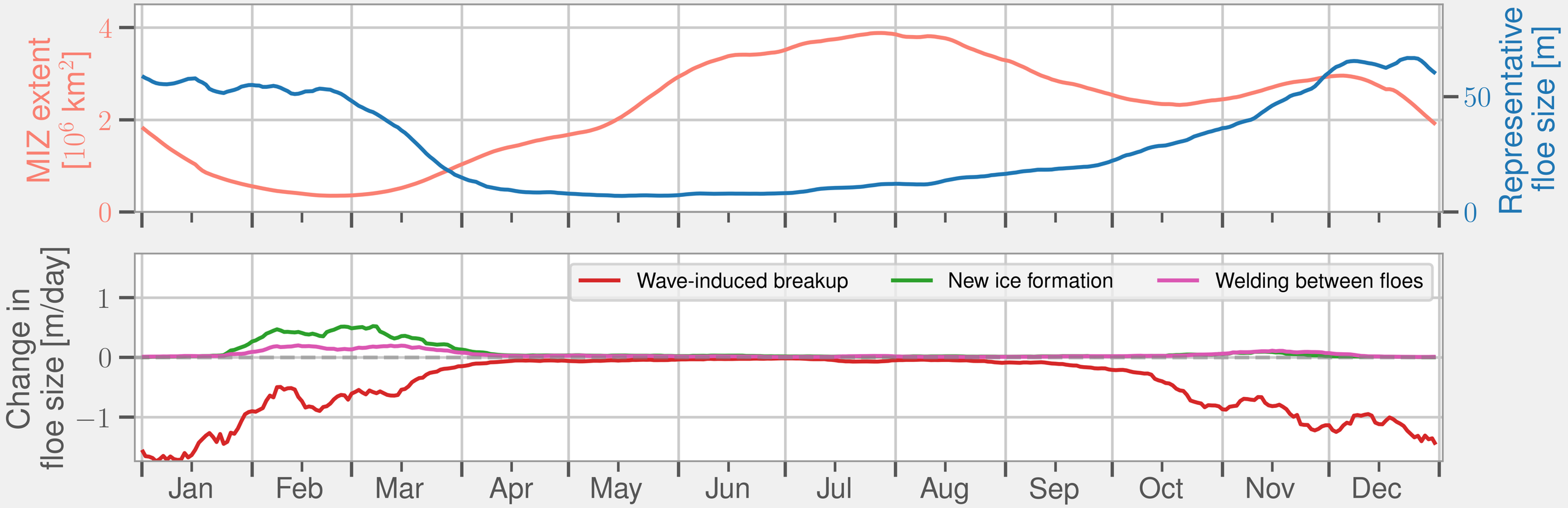
Seasonality of the sea ice clusters

- Thin sheets of young ice form rapidly over the winter before becoming either thicker and larger, or risk becoming broken by waves (MIZ)



Seasonality of the marginal ice zone

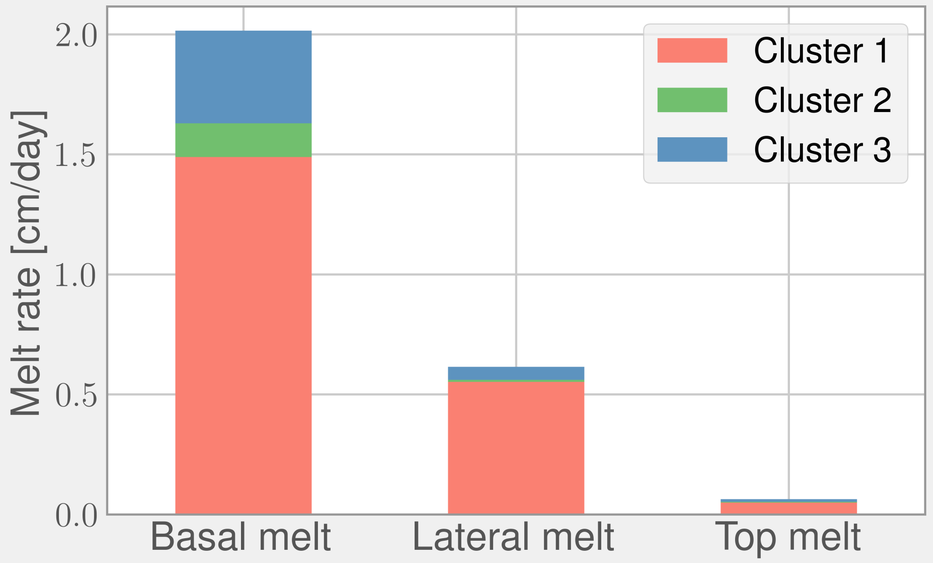
- Unlike with a threshold, the floe size of the unsupervised MIZ is allowed to change over the season
- This captures both the pancake ice formation in the winter and broken floes in the summer



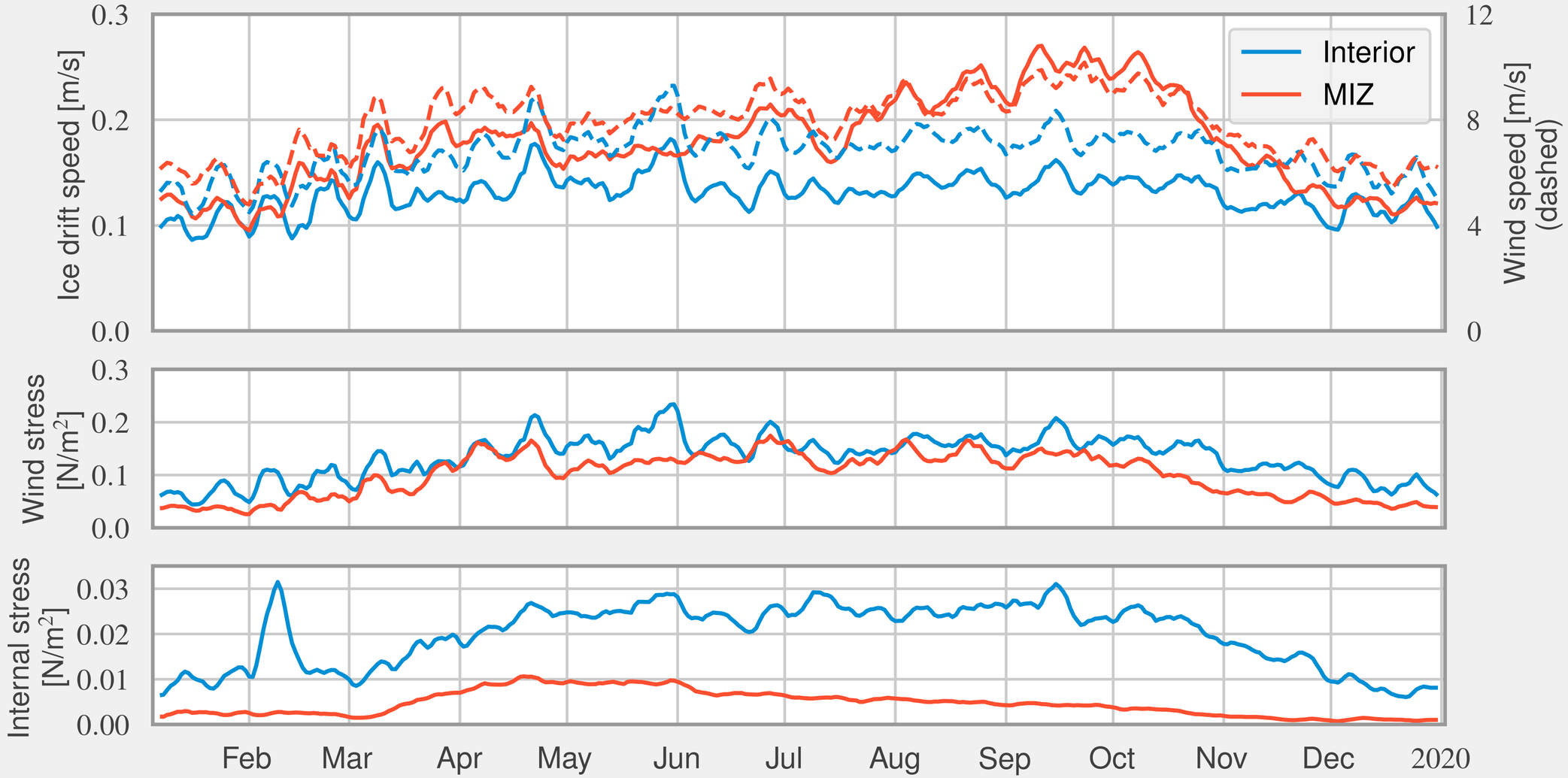
Identification of physical processes

Although our definition is informed only by the ‘ice appearance’, MIZ processes are still identified

- The MIZ dominates the rate of wave-induced breakup and melting of floes
- Meanwhile, the rate of welding and large floe formation occur mostly in the interior regions (clusters 2 and 3)

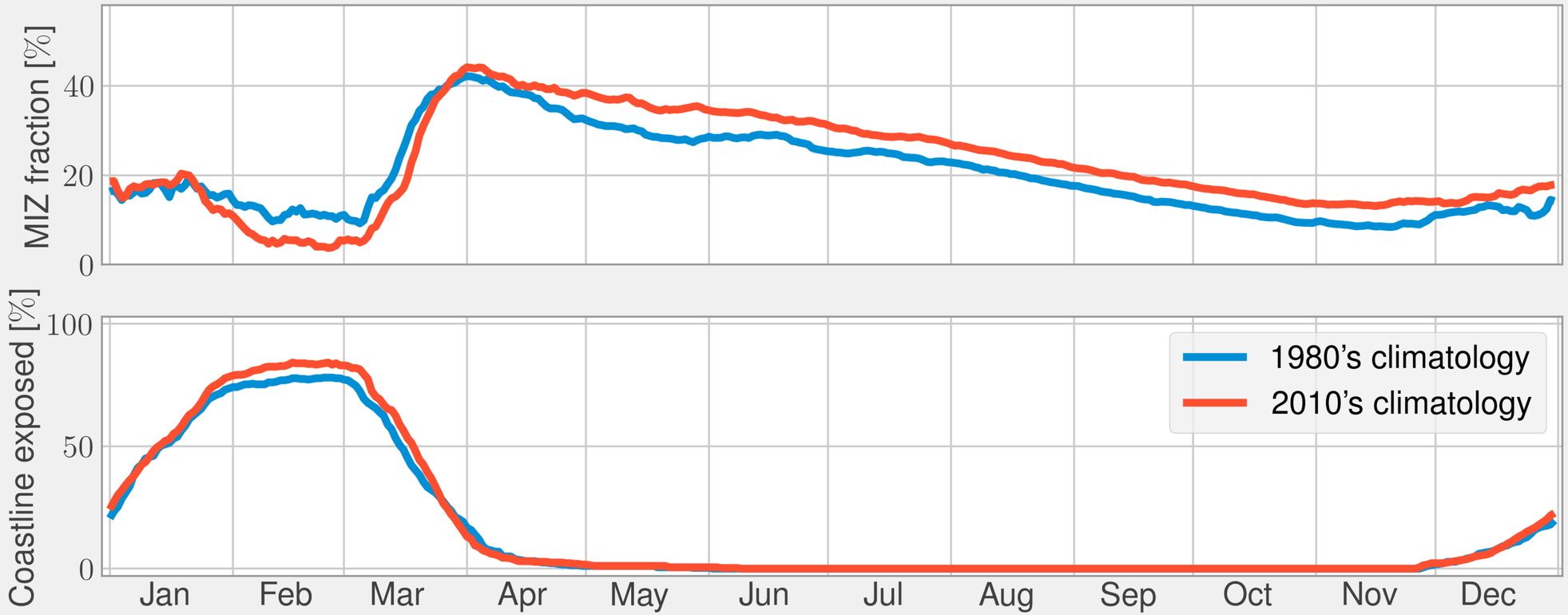


Sea ice dynamics



Responses to climate - preliminary

- Two climatology simulations were completed: (1) 1980's climatology; (2) 2010's climatology
- The MIZ area increased by 15.06 %, and comprises up to 44.1 % of the ice cover



Conclusions

- An unsupervised algorithm (*k*-means) has quantified the Antarctic wave affected marginal ice zone from simulated sea ice data
- The extent of this region agrees with satellite derived waves-in-ice measurements
- This method identified key MIZ physical processes, such as wave breakup, increased melt rates, and ice drift
- This further validates the importance of floe size for identifying areas of wave affected ice

Thanks for listening!

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