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Preface to the *Annals of Glaciology* Collection 'Sea Ice Across Temporal and Spatial Scales'

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Sea ice remains at the centre of public attention worldwide due to its ongoing rapid retreat that affects local and regional climate and ecosystems and people, but also increases the access of the polar oceans for human activities making them the focus of socio-economic planning and potential geopolitical conflict. While the shrinkage of Arctic sea ice coverage has been well documented and much discussed over the past more than forty years, Antarctic sea ice coverage had changed little until recently. However, since 2017, sea ice in Antarctica has shown more rapid decline than ever seen in the Arctic, challenging our attribution of underlying atmospheric and oceanic causes and our ability to predict its future change. Is this the beginning of the rapid end of Antarctic summer sea ice, or has the region just entered a new equilibrium state from where it will continue to vary as before or even return to levels seen before 2017? And despite rapid declines of Arctic sea ice in the last 45 years overall that stimulated many to predict the ice's quick demise, the recent decade or so has seen a pause in ice retreat with little trends. Does this show the impacts of natural variability over anthropogenic change, and what does it mean for our ability to understand and predict interannual and decadal sea ice variability at all?

In order to advance our understanding and predictive capabilities it is important to understand that sea ice properties and processes on wide ranging temporal and spatial scales need to be taken into account. Due to its small and large scale variability and non-linear feedback processes, even small scale processes need to be taken into account to understand larger scale behaviour. Examples include melt ponding, the ice thickness - ice growth feedback (thinner ice grows faster than thicker ice), snow accumulation and redistribution, ice deformation and thickness redistribution, etc. These processes have strong seasonal behaviour, and conditions and interactions are significantly different during the polar night when no sunlight is available for forcing feedbacks related to short wave radiation. Most satellite observations, required for systematic year-round, hemispheric observations, lack sufficient spatial resolution to resolve the small-scale structure of sea ice, and therefore parameterizations are required to up-scale properties and to understand the mixed signals received in space.

Many of the papers in this *Annals of Glaciology* Collection on 'Sea Ice Across Temporal and Spatial Scales' address these issues. The title of the Collection was taken from the International Glaciology Society's International Symposium on Sea Ice Across Temporal and Spatial Scales motto, at which much but not all of this work was presented for the first time. The IGS symposium took place in Bremerhaven, Germany, between 4 and 9 June 2023, and attracted more than 300 participants.

While several of the results presented at the IGS symposium are published elsewhere, the 21 works published in this issue cover subjects from satellite remote sensing (8), large-scale modelling (4), large-scale processes (2), sea ice drift (2), sea ice microphysics including the nature of microwave emissions (4), and ice navigation by ships (1). Thus, this 2024 Collection of the *Annals of Glaciology* presents a nice overview of recent advances and challenges of recent sea ice research that will help to close some of the knowledge gaps mentioned above. The cover image used for this *Annals of Glaciology* Collection is a cropped version of Fig. 1, which depicts sea ice conditions within a nautical mile of the geographic North Pole taken by a drone from ca. 600 m height on 17 September 2024. It shows that melt ponds are already frozen and snowed over, and different types of new ice can be seen between older ice floes that are strewn with pressure ridges. The curved, dark lead is the channel of French icebreaker *Le Commandant Charcot* and symbolizes the increasing accessibility of the central Arctic Ocean.

Figure 1 near here

The Associate Chief Editor (Christian Haas) of this *Annals of Glaciology* Collection would like to thank the editorial staff of the International Glaciological Society for their hard and persistent work to handle and publish all manuscripts, in particular Hester Jiskoot (IGS Chief Editor) and Lynsey Rowland (Editorial Assistant). In addition, we are indebted to our Scientific Editors who served the sea ice community by dedicating much time and effort to assure the continued quality of the scientific review process:

David Babb

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Needless to say, their work would not have been possible without the diligence and critique of the countless, mostly anonymous reviewers that helped to improve the quality and correctness of manuscripts significantly.

Figure 1. Photo of sea ice within a nautical mile of the geographic North Pole taken with a drone from ca. 600 m height on 17 September 2024. The curved, dark lead is the channel of the ice breaker "*Le Commandant Charcot*". Credit: Christian Haas.

Figure 1