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Drivers of Antarctic sea-ice advance date

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Sea-ice advance is a key moment to the Antarctic climate and ecosystem. Over the last 4 decades, sea-ice advance has been occurring earlier in the Weddell and Ross Seas and later west of the Antarctic Peninsula and in the Amundsen Sea. However, not much is known on the drivers of the observed changes nor on the physical processes determining the date of advance in the Southern Ocean. To progress understanding, we investigate the respective roles of ocean-sea ice processes in controlling the timing of sea-ice advance using observational and reanalysis data. Based on the satellite-based sea-ice concentration budget at the time of advance, we identify two regions with distinct processes. In the outermost ice-covered region, a few degrees of latitude within the winter ice-edge, no ice growth is observed and the ice advance date can only occur by transport of ice from higher latitudes. This is consistent with above freezing reanalysis sea surface temperature (SST) at the time of sea-ice advance. Elsewhere in the seasonal ice zone, ice import is a minor contributor to the sea-ice concentration budget hence sea-ice advance must be due to freezing only. *In situ* hydrographic observations show that the date of advance is more strongly linked to the seasonal maximum of the mixed layer heat content (MLH) than to the seasonal maximum SST — which reflects that the need for the full mixed layer to approach freezing before sea ice can appear. The relationship is stronger in regions with no contribution of sea-ice transport. Based on these considerations, we suggest that upper ocean hydrographic properties and sea ice drift are key features to determine the timing of sea-ice advance.