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Wind-driven processes controlling heat delivery to the Amundsen Sea, Antarctica

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Increased delivery of heat by Circumpolar Deep Water (CDW) is responsible for the accelerated basal melting and thinning of the Amundsen Sea ice shelves in recent decades. Troughs cross-cutting the continental shelf provide direct routes by which these waters gain access to the coastal areas. However, the driving mechanisms forcing CDW onto the shelf remain a matter of much debate. Here, a high-resolution regional model is used to investigate the processes governing heat content variability in the Amundsen Sea. Temperature variability is decomposed into that associated with changes in the depth of isopycnals (i.e. heave; HVE) and that linked to temperature changes along isopycnals (i.e. water mass property changes; WMP) to identify the key controlling mechanisms. In the Dotson Trough, WMP-related processes control most of the temperature variability. The deeper thermocline and shallower continental shelf in the western Amundsen Sea hinder CDW access onto the trough. The inflow of new water masses is associated with the uplift of isopycnals at the continental shelf break in response to the presence of an eastward undercurrent, which is primarily forced by the zonal ocean surface stress. In turn, HVE-related processes control temperature variability in the Pine Island Trough. The shallower thermocline and deeper bathymetry there allow CDW to readily access the eastern Amundsen Sea, which is characterised by uniform thermohaline properties. Atmospheric (i.e. Ekman pumping on seasonal time-scales) and ocean circulation (i.e. modulation of deep layer volume by deep water inflows) affect the vertical displacement of isopycnals within this trough. The western and eastern Amundsen Sea thus represent distinct regimes, in which the wind is the primarily controller of the deep-ocean heat content via different dynamics. Our results stress that in order to represent the system realistically, and capture the ocean forcing ice shelf evolution, models need to adequately represent the coupled air-ice-ocean stresses and the undercurrent dynamics, as well as the processes setting the time-mean geometry of the regional thermocline.