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Wind-driven ocean dynamic effects on the contrasting sea-ice trends around West Antarctica

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Since late 1978, Antarctic sea-ice extent in the East Pacific has retreated persistently over the Amundsen and Bellingshausen Seas in warm seasons, but expanded over the Ross and Amundsen Seas in cold seasons, while an almost opposite trend has occurred in the Atlantic over the Weddell Sea. Previous studies have shown that the contrasting sea-ice trends in the East Pacific and Atlantic could be explained by the strengthening Southern Hemisphere (SH) subpolar low over West Antarctica and associated cold- and warm-air advections and sea-ice drift. By using a surface-forced ocean and sea-ice coupled model, we show that regional wind-driven ocean dynamics also played a key role. In the East Pacific, the strengthening SH westerlies in the region enhanced Ekman upwelling of the warm upper Circumpolar Deep Water, which directly contributed to the retreat of sea ice in warm seasons, and increased the northward Ekman transport of cold Antarctic surface water, which supported the expansion of sea ice in cold seasons. In the Atlantic, the northern branch of the Weddell Gyre strengthened due to the poleward shifting SH westerlies in the region. This in turn sharply increased the meridional thermal gradient across it as constrained by the thermal wind balance. Ocean heat budget analysis further suggests that the strengthened northern branch of the Weddell Gyre acted as a barrier against the poleward ocean heat transport, and thus produced anomalous heat divergence within the Weddell Gyre and anomalous heat convergence north of the gyre. The associated cooling within the Weddell Gyre and the warming north of the gyre contributed to the expansion of sea ice in warm seasons and the retreat in cold seasons, respectively.