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Atmospheric Drivers of Melt on Larsen C Ice Shelf: Surface Energy Budget Regimes and the Impact of Foehn

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Recent ice shelf retreat on the east coast of the Antarctic Peninsula has been principally attributed to atmospherically driven melt. However, previous studies on the largest of these ice shelves—Larsen C—have struggled to reconcile atmospheric forcing with observed melt. This study provides the first comprehensive quantification and explanation of the atmospheric drivers of melt across Larsen C, using 31 months' worth of observations from Cabinet Inlet, a 6-month, high-resolution atmospheric model simulation and a novel approach to ascertain the surface energy budget (SEB) regime. The dominant meteorological controls on melt are shown to be the occurrence, strength, and warmth of mountain winds called foehn. At Cabinet Inlet, foehn occurs 15% of the time and causes 45% of melt. The primary effect of foehn on the SEB is elevated turbulent heat fluxes. Under typical, warm foehn conditions, this means elevated surface heating and melting, the intensity of which increases as foehn wind speed increases. Less commonly—due to cooler-than-normal foehn winds and/or radiatively warmed ice—the relationship between wind speed and net surface heat flux reverses. This explains the seemingly contradictory results of previous studies. In the model, spatial variability in cumulative melt across Larsen C is largely explained by foehn, with melt maxima in inlets reflecting maxima in foehn wind strength. However, most accumulated melt (58%) occurs due to solar radiation in the absence of foehn. A broad north-south gradient in melt is explained by the combined influence of foehn and non-foehn conditions.