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Extreme wintertime surface energy budget anomalies in the high Arctic

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In recent decades the Arctic has warmed faster than the global mean, especially during winter. Wintertime Arctic warming has been attributed to various mechanisms, with recent studies highlighting the important role of enhanced downward infrared radiation associated with anomalous influx of warm, moist air from lower latitudes. Here we study wintertime surface energy budget (SEB) anomalies over Arctic sea ice on synoptic time scales, using ERA5 reanalysis data (1979-2020). With a new algorithm introduced here, we identify regions exhibiting large positive daily-mean SEB anomalies, and temporally connect them to form life-cycle events. Using Lagrangian tracers, we show that the majority of these winter events are associated with inflow from the Atlantic or Pacific Oceans, driven by the large-scale circulation. They show similar temporal evolution. The onset stage, located around the marginal ice zone, is characterized by roughly equal contributions of net longwave radiation and turbulent fluxes to the positive SEB anomaly. As the events evolve and move further into the Arctic, SEB anomalies decrease due to weakening sensible heat fluxes as the surface adapts. The magnitude of the surface temperature anomaly is determined by the downward longwave radiative flux and changes little over the life-cycle. As this study highlights the importance of turbulent fluxes in driving SEB anomalies and downward longwave radiation in determining local surface warming, both components need to be properly represented by climate models in order to properly model the Arctic climate.