Cooling the coldest continent: The 4 December 2021 Total Solar Eclipse over Antarctica

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Total solar eclipses (TSEs) are impressive astronomical events which have attracted people's curiosity since ancient times. Their abrupt alterations to the radiation balance have stimulated studies on "Eclipse Meteorology," most of them documenting events in the Northern Hemisphere while only one TSE (23 November 2003) has been described over Antarctica. On 4 December 2021– just a few days before the austral summer solstice– the moon blocked the sun over the austral high latitudes, with the path of totality arching from the Weddell Sea to the Amundsen Sea, thus producing a ~2-minute central TSE. In this work we present high resolution meteorological observations from Union Glacier Camp (80°S, 83°W), the only location with a working station under totality, and South Pole station. These observations were complemented with meteorological records from 40 surface stations across Antarctica. Notably, the largest cooling (~5°C) was observed over the East Antarctic dome, where obscurity was ~85% while many sectors experienced insignificant temperature changes. This heterogenous cooling distribution, at odds with the seemingly homogeneous land-surface of Antarctica, is partially captured by a simple radiative model. To further diagnose the effect of the eclipse on the surface meteorology we ran multiple pairs of simulations (eclipse-enabled and -disabled) using the Weather Research & Forecast model. The overall pattern and magnitude of the simulated cooling agree well with the observations and reveals that, in addition to the solar radiation deficit and cloud cover, low-level winds and the height of the planetary boundary layer are key determinants of the temperature changes and their spatial variability.