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Mechanisms behind synoptic-scale variability in South Pole surface meteorology from observations and a regional model

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The climate and weather over the Antarctic ice sheet are simulated during 1994-2002 using Modèle Atmosphérique Régional (MAR), a three-dimensional meso-scale primitive equation model with detailed cloud ice microphysics. The model is forced at its boundaries by reanalysis data (ERA-40 from the European Centre for Medium-Range Weather Forecasts). The model output is compared to high temporal resolution data (hourly to daily) from the South Pole. Using a combination of wavelet, cluster, and regression techniques, we present an evaluation of MAR's representation of meteorological parameters. In general, MAR simulates the annual means and spectral variances of synoptic variables correctly (e.g. temperature, wind speed, longwave downwelling fluxes). However, the actual timing and character of synoptic events is different between the model grid cell over South Pole and surface-based point observations. In addition, the seasonal means of fields such as surface temperature and longwave downwelling fluxes are biased low during summer likely due to an underestimate of summertime cloud cover. Cluster analysis shows a single, clear pattern during cold events: low tropospheric humidity, clear skies, and low longwave downwelling flux. MAR simulates the preferred near-surface and upper tropospheric wind direction and speed well during cold events. The near-surface wind direction ranges mostly from grid NE to grid E, representing the inversion wind. In the upper troposphere the wind under cold conditions is mostly from grid SE and weak. Cluster analysis also shows that warm events result from several different synoptic influences. Most warm events during winter are associated with a large increase in tropospheric specific humidity and tropospheric cloud liquid water content caused by the warm air advection. The upper tropospheric wind becomes stronger compared to the cold events and has a range of directions from the grid NW to SW indicating different origins of the warm advection. The near-surface wind direction also shows variable direction during warm events, ranging from grid N to grid NW. A special category of warm events simulated by MAR was found during the latter half of the winter, when surface warming was associated with high ice content in stratospheric clouds.