The McMurdo Dry Valleys (hereafter “MDVs”) are the largest ice-free region in Antarctica, featuring perennially ice-covered lakes that are fed by ephemeral melt streams in the summer. The MDVs have been an NSF-funded Long-Term Ecological Research (LTER) site since 1993, and LTER research has shown that the hydrology and biology of the MDVs are extremely sensitive to small climatic fluctuations, especially during summer when temperatures episodically rise above freezing. However, the atmospheric processes that control MDVs summer climate, namely the foehn and sea-breeze regimes, are not well understood. Here we present results from 15 summers of Polar WRF simulations that focus on the spatial and temporal variability of MDVs climate. The Polar WRF simulations have been tailored for use in the MDVs through modifications to the input soil conditions, snow cover, land use, and sea ice. Differences in the spatial distribution and strength of foehn and sea breeze events across the MDVs are examined from the evolution of individual events in the model fields. The large-scale circulation is found to have the greatest influence on the mesoscale response within the MDVs. Differences in foehn and sea breeze day distributions with time (monthly and annually) are primarily determined through Southern Hemisphere large-scale climate variability (e.g., SAM and ENSO) and the associated variability of cyclone activity in the Ross Sea sector. The results of this study allow for a physical interpretation of MDVs climate variability as an important harbinger of climate change in Antarctica.