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Observational and numerical analysis of atmospheric boundary-layer response to summertime thermal and dynamic forcings in Miers Valley, Antarctica

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In response to solar insolation the McMurdo Dry Valleys (MDVs) summertime airflow patterns show bimodal oscillations, either up-valley or down-valley. Miers Valley (78°6'S, 164°0'E) is one of the four, east-west oriented ice-free valleys in the Denton Hill area of southern Victoria Land and one of the biodiversity 'hotspots'. This glacially excavated valley is considerably smaller than the larger valley systems such as Wright or Victoria.
While most atmospheric research has been carried out in the larger valley systems, little work has been done on this part of the MDVs; this research presents the first investigation of Miers valley's microclimate. We aim to provide insight into diurnal evolution of boundary layer and physical mechanism(s) responsible for local circulations, and determine their spatial extent during summer 2012 (13-25 January). This was achieved through high-resolution numerical modeling using a polar optimized weather prediction model (PWRF) alongside data obtained from an eddy-covariance system and a wind profiler (SODAR) to elucidate the role of local thermal forcing during synoptic quiescence. Measurements showed that persistent up-valley winds were present within and above a mixed layer (120 $\pm$ 30 mAGL), peaking around 75 mAGL upto 6 m/s between 1800 to 2000 LST. Several mechanisms that can produce up-valley flows in MDVs have been proposed. A regional intrusion of sea breeze currents originating from McMurdo Sound and the Ross Sea area is one of the possible forcings for such valley winds. Another suggested forcing is flow deflection due to the blocking effect of Ross Island (RI).
Numerical simulations confirm that up-valley easterlies have both local and regional thermal and dynamic forcings. The thermal forcing is controlled by the variation in solar elevation, topographic shadowing, and clouds, which cause a heterogeneous thermal pattern and produce a cross-valley thermal gradient, and spatially larger gradient between the valley atmosphere and the Ross Ice Shelf (RIS) forcing the local wind system. PWRF simulates different spatial wind pattern for each half of the valley, mainly because of the shape of topography and the distance from RIS. The eastern half of the valley constantly showed up-valley wind whereas the valley interior, (which includes the measurement site) experienced a weak and shallow down-valley flow when the surface is topographically shadowed. The dynamic forcing results from the build-up of a meso-high pressure zone south of RI due to katabatic interaction with topography and the channeling effect of RI and the adjacent coastal topography, which cause intrusion of an easterly flow against the pressure gradient pattern lying over the nearby Koettlitz Glacier.