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The Effects of Cloud Cover on the Stable Boundary Layer in Spring and Summer at the South Pole and Implications for Surface Chemistry

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The absence (or presence) of clouds in the summer, at 90S, plays a key role in surface chemistry. A recent paper (Neff et al. 2017 ACPD) explored the various factors underlying the occurrence of extremes in the concentrations of nitrogen oxide (NO) which arise from the UV photolysis and recycling of nitrate near the surface of the snow. Past work has shown that these concentrations are largest with shallow boundary layers. Here we explore the role that clouds play in modulating NO concentrations via the response of the boundary layer depth to the surface energy budget. With conditions of warm and moist air advection the boundary layer grows in depth often forming a deep boundary layer that is nearly isothermal with a capping inversion resulting in low concentrations. As clouds clear, the surface cools rapidly often forming a stable boundary layer less than 10-m deep. Such modulation via clouds clearly implicates meso- to synoptic scale circulations over the ice sheet. In particular, Neff et al. 2017 found that winds aloft at 300-hPa control the boundary layer flows and can be related to extremes in cloudiness as well as local circulations and evolve in a distinct fashion from winter to summer over the South Pole. In addition they found that periods of clear skies were most likely in late November coincident with the typical persistence, now much later in the year, of depleted ozone in the stratosphere. The low column ozone and resulting higher actinic flux responsible for nitrate photolysis now coincides with optimum boundary layer conditions for accumulation of NO in shallow layers. In this presentation we will also explore some of the unknowns in our understanding relating to the issues of geographical distribution of shallow boundary layers, the role of clouds and the mesoscale circulations that live over the surface of Antarctica.
Reference: Neff, W., J. Crawford, M. Buhr, J. Nicovich, G. Chen, and D. Davis (submitted posthumously), The Meteorology and Chemistry of High Nitrogen Oxide Concentrations in the Stable Boundary Layer at the South Pole, 2017, ACPD doi.org/10.5194/acp-2017-812.