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The Role of Katabatic Flows and Synoptic Forcing on the Export of NO-NOX from Antarctica in the Austral Summer

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The Antarctic Tropospheric Chemistry Investigation (ANTCI) carried out two major field programs at the South Pole from late November through December. The first of these was in 2003 [Davis et al., 2008] and the second occurred in 2005 [Slusher et al., 2010]. Both studies included small-aircraft measurements of key chemical constituents in the boundary layer several hundred km from the Pole which revealed that the high NO concentrations seen at the Pole were also ubiquitous in its immediate vicinity. In particular, the 2005 ANTCI aircraft probing of the high plateau, as reported by [Slusher et al., 2010], found high concentrations of NO over a much larger portion of the plateau where sampling reached nearly to Vostok Station.

As part of both studies, a few of the flights probed portions of the katabatic outflow regions over Byrd and Reeves Glaciers, seeking evidence of export of NO_x from the continent. On 11-27-2003, a flight was made in the drainage flow from Byrd Glacier during which very high concentrations of NO ($\sim$500 pptv) and NO_y were observed. However, a second r flight one day later did not reveal a similar plume of NO suggesting that the export due to katabatic flow was intermittent. On 11-21/22-2005, flights were also made over Reeves and David Glaciers and on 12-12-2005 over Byrd Glacier. These observations and those for O_3 showed smaller but still well-defined increases while traversing Reeves glacier at multiple heights. Similarly a single flight on 12-12-2005 above Byrd Glacier showed NO reaching 70 pptv over the center of the glacier with a well defined plume centered along the axis of the glacier. These results suggested a need for a closer examination of mechanisms controlling export of NO_x and oxidants from the high plateau to coastal areas.

Katabatic outflow from the high plateau of East Antarctic has been well documented during the Austral winter [Breckenridge et al., 1993] where satellite imagery provides highly visual images of cold air surges across the Ross Ice Shelf [Bromwich, 1989]. In these cases, the cold surface of the ice sheet is disturbed by high surface winds, creating a warm signature that is revealed convincingly in satellite infrared imagery. However, similar analyses have been lacking in the summer season when photochemistry over the interior of the ice sheet is much more active.

In this presentation we will examine potential controlling mechanisms for this intermittent transport during the summer season including:

1. Synoptic pressure gradients that inhibit downslope flow from the interior and allow, under clear sky and light to moderate wind conditions, the accumulation of NOX-rich air in the boundary layer.
2. A change in the synoptic conditions that allows a release of this cold air to flow down through the glacial valleys to the Ross Sea.
3. An examination of METOP high-resolution infrared satellite data for the summer seasons (late-November-December) available during 2012 and 2013 that show katabatic outflow signatures extending over 100 km over the Ross Sea (compared to as much as 500 km during the winter season). Note, these events are typically preceded by light winds and colder temperatures over the interior as seen in AWS data from the high plateau.
4. Back-trajectory analysis that show many of these air streams near the exit of the Byrd Glacier originated on the plateau grid east of the South Pole.

Finally, we discuss future experiments that may better resolve the underlying mechanisms and the frequency of these events. This includes better placement of AWS stations in key glacial outflow areas, small UAS probing the glacial airflow, and small aircraft profiling across the outflow regions with real-time NOX and O_3 measurements. Also useful would be a determination of a concomitant signature in ozone as measured by a downward looking ozone lidar onboard a small aircraft.

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