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Nitric acid in the stratosphere based on Odin observations from 2001 to 2009 – Part 2: High-altitude polar enhancements

Y. J. Orsolini[1], J. Urban[2], and D. P. Murtagh[2]
[1]Norwegian Institute for Air Research, Kjeller, Norway
[2]Chalmers University of Technology, Department of Radio and Space Science, Göteborg, Sweden

Abstract. The wintertime abundance of nitric acid (HNO_3) in the polar upper stratosphere displays a strong inter-annual variability, and is known to be strongly influenced by energetic particle precipitation (EPP), primarily by protons during solar proton events (SPEs), but also by precipitating auroral or relativistic electrons. We analyse a multi-year record (August 2001 to April 2009) of middle atmospheric HNO_3 measurements by the Sub-Millimeter Radiometer instrument aboard the Odin satellite, with a focus on the polar upper stratosphere. SMR observations show clear evidence of two different types of polar high-altitude HNO_3 enhancements linked to EPP. In the first type, referred to as direct enhancements by analogy with the EPP/NO_x direct effect, enhanced HNO_3 mixing ratios are observed for a short period (1 week) after a SPE, upwards of a level typically in the mid-stratosphere. In a second type, referred to as indirect enhancements by analogy with the EPP/NO_x indirect effect, the descent of mesospheric air triggers a stronger and longer-lasting enhancement. Each of the three major SPEs that occurred during the Northern Hemisphere autumn or winter, in November 2001, October–November 2003 and January 2005, are observed to lead to both direct and indirect HNO_3 enhancements. On the other hand, indirect enhancements occur recurrently in winter, are stronger in the Southern Hemisphere, and are influenced by EPP at higher altitudes.

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