Changes in HO\textsubscript{x} and NO\textsubscript{y} Species During Solar Proton Events: Analysis and Parameterization

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Abstract. In the middle atmosphere, enhanced ionization by precipitating particles leads to changes in minor neutral composition through ion chemistry. For example, nitrogen and water vapor molecules are dissociated, and odd hydrogen (HO\textsubscript{x} = H + OH + HO\textsubscript{x}) and odd nitrogen (NO\textsubscript{y} = N + NO + NO\textsubscript{y}) species are produced. Increase in HO\textsubscript{x} and NO\textsubscript{y} concentrations can then boost the catalytic reaction cycles that destroy ozone.

In this paper, we utilize the Sodankylä Ion and Neutral Chemistry model (SIC), which combines ion and neutral chemistry for particle precipitation studies. Based on an analysis of the SIC chemistry, we demonstrate how positive ion chemistry produces NO\textsubscript{y} and HO\textsubscript{x}, while negative ion chemistry redistributes NO\textsubscript{y} species by converting NO\textsubscript{y} and N\textsubscript{2}O\textsubscript{3} to HNO\textsubscript{3} and NO\textsubscript{y}.) Recent SIC results on OH and HNO\textsubscript{3} during solar proton events are presented, including comparisons with satellite instruments. We put forward an improved parameterization, which takes into account both positive and negative ion chemistry and can be used to model the effects of particle precipitation.

THE SIC MODEL

MODEL-SATELLITE COMPARISON

ION CHEMISTRY PARAMETERIZATION

\[ P/Q = \left(\frac{P_{\text{obs}} - L_{\text{app}}}{P_{\text{ref}} - L_{\text{app}}}\right) \]

Above: The production rates of, e.g., OH and HNO\textsubscript{3} can be calculated from SIC model results considering production (\textit{P}) and loss (\textit{L}) processes. Below: Examples of P/Q number, NH, January, Q = 100 cm\textsuperscript{-3} s\textsuperscript{-1}.

Below: A diagram of hydrogen and nitrogen conversions due to ionic reactions. The species in the gray boxes are affected by positive ion chemistry, while NO\textsubscript{y} redistribution by negative ion chemistry affects the species inside the blue box. NO\textsubscript{y}, HNO\textsubscript{3}, and H\textsubscript{2}O are directly affected by both positive and negative ion chemistry. Note that all neutral reactions, e.g., production of NO from N\textsubscript{2}O\textsubscript{3}, are not included in the diagram.

References

