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Martian atmospheric chemistry of HCl: implications for the lifetime of atmospheric methane

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We develop a 1-D atmospheric photochemistry model for Mars to interpret hydrogen chloride (HCl) profile measurements collected by the ACS MIR spectrometer aboard the ExoMars Trace Gas Orbiter (TGO) in Mars Year (MY) 34. We include a gas-phase chlorine chemistry scheme and study 1) surface chemistry, 2) hydrolysis, 3) photolysis, and 4) hydration and photolysis of dust grains as possible sources of gas-phase chlorine chemistry. Heterogeneous uptake of chlorine species onto water ice and minerals in Martian dust are loss processes common to all mechanisms. We drive the 1-D model using TGO profile measurements of aerosols and water vapour. We find that mechanism four can reproduce observed HCl profile tendencies during MY34. It reproduces the HCl cut-off at high southern latitudes (<60° S) at ≈35 km, and forms layers of HCl between 20-35km at the tropics. Mechanisms one, two, and three result in significant model biases.

Seasonal variations of Martian HCl are reproduced by mechanism four, yielding low HCl abundances (< 1 ppb) prior to the dust season that rise to 2--6 ppb in southern latitudes during the dust season. We find that the additional Cl atoms released via mechanism four shortens the atmospheric lifetime of methane by a magnitude of 10^2. This suggests the production of Cl via the UV (or other electromagnetic radiation) induced breakdown of hydrated perchlorate in airborne Martian dust, consistent with observed profiles of HCl, helps reconcile observed variations of methane with photochemical models.