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Recent Increases in Stratospheric HCl: Stratospheric Dynamics versus the Montreal Protocol

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Long-lived chlorine-containing source gases, such as chlorofluorocarbons (CFCs), are transported into the stratosphere where they decompose and cause ozone depletion. Increases in chlorine during the 1970s-1990s resulted in long-term ozone decreases, especially in the polar regions. Following the implementation of the Montreal Protocol, the near-surface chlorine loading was observed to peak in 1993 and, since then, to decrease in line with expectations. After release from source gases in the stratosphere, chlorine mainly forms the reservoir HCl, providing an alternative method for monitoring the progress of the Montreal Protocol.

A maximum in stratospheric HCl was observed around 1996, followed by decay at a rate close to 1%/year, consistent with the tropospheric chlorine peak and known transport timescales. However, we will present total column observations from ground-based FTIR instruments which show an unexpected and significant upturn in stratospheric HCl around 2007 in the northern hemisphere. Height-resolved observations from satellite instruments (HALOE, MLS, ACE) confirm this increase and show that it occurs in the lower stratosphere. These observations contrast with the ongoing monotonic decrease of near-surface chlorine source gases.

Using 3-D model simulations (TOMCAT/SLIMCAT and KASIMA) we attribute this trend anomaly to a slowdown in the NH atmospheric circulation, causing air in the lower stratosphere to become more aged with a larger relative conversion of source gases to HCl. An important conclusion is that the Montreal Protocol is still on track and will still lead to long-term decreases in stratospheric chlorine. This dynamical variability could also significantly affect the evolution of stratospheric ozone and must be accounted for when searching for signs of ozone recovery.