Impact of halogens on ozone in the lower stratosphere

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Chlorine and bromine species are known to cause depletion of the ozone layer. Depletion of upper stratospheric ozone by chlorine was the basis for initial concern over chlorofluorocarbons (CFCs) in the 1970s. Chlorine and bromine species cause the large seasonal depletion in the springtime Antarctic lower stratosphere (the ‘ozone hole’), with similar processes occurring during cold Arctic winters. Chlorine and bromine can also contribute to the relatively small ozone depletion in the extra-polar lower stratosphere over decadal timescales. These chlorine and bromine species are largely derived from long-lived source gases (e.g. CFCs and others) which are now controlled by the Montreal Protocol. As a result, stratospheric chlorine and bromine loadings are decreasing and the ozone layer is showing signs of recovery. However, chlorine and bromine can also be transported to the stratosphere by very short-lived species (VSLS) – compounds such as dichloromethane with atmospheric lifetimes of less than 6 months.

I will present model results which show the impact of the chlorinated and brominated VSLS on stratospheric ozone over the past few decades. I will discuss the sensitivity of ozone to these species in different atmospheric regions and the impact of increasing VSLS levels on ozone recovery. I will also discuss the possibility that iodine reaches the stratosphere and has contributed to ozone depletion. I will frame these results in the context of possible impacts of halogens from other sources such as volcanic eruptions and rocket emissions, and also link them to the climate impact. Finally, I will discuss the current and evolving impact of the eruption of the Hunga Tonga–Hunga Haʻapai volcano in January 2022. This emitted huge quantities of water vapour, and some SO2, into the stratosphere. Our model simulations suggest that this water vapour will persist in the stratosphere for 5-10 years and will enhance the halogen-catalysed depletion of polar ozone through increased occurrence of polar stratospheric clouds.