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Stratospheric cooling and polar ozone loss due to H_2 emissions of a global hydrogen economy

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"Green" hydrogen is seen as a major element of the future energy supply to reduce greenhouse gas emissions substantially. However, due to the possible interactions of hydrogen (H_2) with other atmospheric constituents there is a need to analyse the implications of additional atmospheric H_2 that could result from hydrogen leakage of a global hydrogen infrastructure.

Emissions of molecular H_2 can occur along the whole hydrogen process chain which increase the tropospheric H_2 burden. Across the tropical tropopause H_2 reaches the stratosphere where it is oxidised and forms water vapour (H_2O). This causes increased IR-emissions into space and hence a cooling of the stratosphere. Both effects, the increase of stratospheric H_2O and the cooling, enhances the potential of chlorine activation on liquid sulfate aerosol and polar stratospheric clouds (PSCs), which increase polar ozone destruction. Hence a global hydrogen economy could provoke polar ozone loss and could lead to a substantial delay of the current projected recovery of the stratospheric ozone layer.

Our investigations show that even if 90% of the current global fossil primary energy input could be replaced by hydrogen and approximately 9.5% of the product gas would leak to the atmosphere, the ozone loss would be increased between 15 to 26 Dobson Units (DU) if the stratospheric CFC loading would retain unchanged. A consistency check of the used approximation methods with the Chemical Lagrangian Model of the Stratosphere (CLaMS) shows that this additional ozone loss can probably be treated as an upper limit. Towards more realistic future H_2 leakage rate assumptions ($< 3\%$) the additional ozone loss would be rather small (≤ 10 DU). However, in all cases the full damage would only occur if stratospheric CFC-levels would retain unchanged. Due to the CFC-prohibition as a result of the Montreal Protocol the forecasts suggest a decline of the stratospheric CFC loading about 50% until 2050. In this case our calculations show that the addition effect would account for only less than 4 DU which is equivalent to 1% of the current unperturbed ozone layer over the polar regions (≈ 400 DU). Hence the risk of a substantial damage to the stratospheric ozone layer due to H_2-emissions of a hydrogen economy is low compared to the positive climate implications that would evolve from the avoidance of greenhouse gas emissions.