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Arctic ozone loss and climate change

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While in the southern hemisphere near complete removal of ozone in the lower stratosphere results in an ozone hole virtually every year, the degree of loss in the Arctic is very variable and is typically much smaller. Based on data from a network of ozone sounding stations we show that new records of Arctic ozone loss have occurred every few years (1996, 2000, 2005). in early 2011 chemical destruction of ozone over the Arctic was comparable to that in Antarctic ozone holes for the first time. Unprecedented near complete (~80%) loss occurred in a broad vertical range in the lower stratosphere. On an interannual basis the degree of Arctic ozone loss is mainly governed by the meteorological conditions in the Arctic lower stratosphere in winter/spring. We show that the total loss of ozone in a given winter is closely linked to V_PSC, the winter averaged volume of air, which has been cold enough to allow efficient conversion of chlorine reservoir species into ozone destroying radical forms. V_PSC can be determined from radiosonde measurements since the mid-1960s. We show that the values of V_PSC in those winters which define the cold end of the interannual variability have increased substantially over the past 45 years, leading to recent values of V_PSC, which are more than a factor of three larger than the maximum values reached in the late 1960s and 1970s. We show that this change in climatic conditions in the Arctic stratosphere contributed to the occurrence of record ozone losses since the mid-1990s. This long term change of V_PSC, essentially the tendency that the cold Arctic winters have become substantially colder over the past decades, raises the question whether increasing degrees of Arctic ozone loss can occur, leading to the regular formation of Arctic ozone holes during the next decades, despite slowly decreasing levels of ozone depleting substances in the atmosphere during that time. Understanding what determines the long term evolution of temperatures in the Arctic lower stratosphere during winter is one of the greatest challenges of polar ozone research. We will discuss a potential dynamical feedback mechanism that could amplify the direct radiative cooling effect of increasing greenhouse gas concentrations sufficiently to result in the observed trend in V_PSC.