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Ozone loss and chlorine activation in the Arctic winters 1991-2003 derived with the tracer-tracer correlations

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Abstract. Chemical ozone loss in the Arctic stratosphere was investigated for the twelve years between 1991 and 2003 employing the ozone-tracer correlation method. For this method, the change in the relation between ozone and a long-lived tracer is considered for all twelve years over the lifetime of the polar vortex to calculate chemical ozone loss. Both the accumulated local ozone loss in the lower stratosphere and the column ozone loss were derived consistently, mainly on the basis of HALOE satellite observations. HALOE measurements do not cover the polar region homogeneously over the course of the winter. Thus, to derive an early winter reference function for each of the twelve years, all available measurements were additionally used; for two winters climatological considerations were necessary. Moreover, a detailed quantification of uncertainties was performed. This study further demonstrates the interaction between meteorology and ozone loss. The connection between temperature conditions and chlorine activation, and in turn, the connection between chlorine activation and ozone loss, becomes obvious in the HALOE HCl measurements. Additionally, the degree of homogeneity of ozone loss within the vortex was shown to depend on the meteorological conditions.

Results derived here are in general agreement with the results obtained by other methods for deducing polar ozone loss. Differences occur mainly owing to different time periods considered in deriving accumulated ozone loss. However, very strong ozone losses as deduced from SAOZ for January in winters 1993-1994 and 1995-1996 cannot be identified using available HALOE observations in the early winter. In general, strong accumulated ozone loss was found to occur in conjunction with a strong cold vortex containing a large volume of possible PSC existence (V_{PSC}), whereas moderate ozone loss was found if the vortex was less strong and moderately warm. Hardly any ozone loss was calculated for very warm winters with small amounts of V_{PSC} during the entire winter. This study supports the linear relationship between V_{PSC} and the accumulated ozone loss reported by Rex et al. (2004) if V_{PSC} was averaged over the entire winter period. Here, further meteorological factors controlling ozone loss were additionally identified if V_{PSC} was averaged over the same time interval as that for which the accumulated ozone loss was deduced. A significant difference in ozone loss (of ≈36DU) was found due to the different duration of solar illumination of the polar vortex of at maximum 4 hours per day in the observed years. Further, the increased burden of aerosols in the atmosphere after the Pinatubo volcanic eruption in 1991

significantly increased the extent of chemical ozone loss.

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