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Dynamics and chemistry of vortex remnants in late Arctic spring 1997 and 2000: Simulations with the Chemical Lagrangian Model of the Stratosphere (CLaMS)

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Abstract. High-resolution simulations of the chemical composition of the Arctic stratosphere during late spring 1997 and 2000 were performed with the Chemical Lagrangian Model of the Stratosphere (CLaMS). The simulations were performed for the entire northern hemisphere on two isentropic levels 450 K (~18 km) and 585 K (~24 km).

The spatial distribution and the lifetime of the vortex remnants formed after the vortex breakup in May 1997 display different behavior above and below 20 km. Above 20 km, vortex remnants propagate southward (up to 40°N) and are "frozen in'' in the summer circulation without significant mixing. Below 20 km the southward propagation of the remnants is bounded by the subtropical jet. Their lifetime is shorter by a factor of 2 than that above 20 km, owing to significant stirring below this altitude. The behavior of vortex remnants formed in March 2000 is similar but, due to an earlier vortex breakup, dominated during the first 6 weeks after the vortex breakup by westerly winds, even above 20 km.

Vortex remnants formed in May 1997 are characterized by large mixing ratios of HCl indicating negligible, halogen-induced ozone loss. In contrast, mid-latitude ozone loss in late boreal spring 2000 is dominated, until mid-April, by halogen-induced ozone destruction within the vortex remnants, and subsequent transport of the ozone-depleted polar air masses (dilution) into the mid-latitudes. By varying the intensity of mixing in CLaMS, the impact of mixing on the formation of $ClONO_2$ and ozone depletion is investigated. We find that the photochemical decomposition of HNO_3 and not mixing with NO_x-rich mid-latitude air is the main source of NO_x within the vortex remnants in March and April 2000. Ozone depletion in the remnants is driven by ClO_x photolytically formed from $ClONO_2$. At the end of May 1997, the halogen-induced ozone deficit at 450 K poleward of 30°N amounts to ~12% with ~10% in the polar vortex and ~2% in well-isolated vortex remnants after the vortex breakup.

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