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The relative importance of gas-phase and heterogeneous processes for polar chlorine activation and subsequent ozone depletion

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Polar stratospheric cloud (PSC) particles are composed of different compounds and exist both in crystalline and in liquid form. Heterogeneous reactions occur on the surfaces and in the bulk of PSCs; these reactions are a prerequisite of polar halogen catalysed ozone loss. Both the formation of PSC particles and their heterogeneous reactivity is strongly temperature dependent. Here we discuss under which conditions the heterogeneous reactivity, and thus the composition of PSC particles, is important for polar ozone loss and under which conditions the speed of gas-phase reactions is rate limiting for chlorine activation and polar ozone loss. We discuss different cases of chlorine activation, both for the Arctic and the Antarctic. We find that for a variety of conditions, including the onset of chlorine activation in early winter, the subsequent completion of chlorine in the course of winter, and in the period of very rapid ozone loss in Antarctic spring, the speed of heterogeneous reactions is not a controlling factor for activation and subsequent ozone loss. However, we present also a case in
Arctic spring, where gas-phase and heterogeneous reactions compete. Further, a sensitivity simulation is performed with the chemistry-climate model EMAC; it can be shown that the significance of heterogeneous reactions on ice particles, in comparison to liquid particles, is subordinate regarding chlorine activation and ozone depletion in Antarctic spring.