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Simulations of chlorine activation on TiO_2 particles in the context of geo-engineering strategies: Impact in a future reduced-chlorine stratosphere

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The term 'geoengineering' can be defined as the intentional manipulation of the environment to counteract the negative impacts of the global warming. Research in this topic was stimulated in August 2006 when Nobel laureate Paul Crutzen published an article which reinvigorated the debate around "solutions" to escalating climate change. Solar radiation management (SRM) techniques are among them. Their aim is to enhance the back-scattering of incoming radiation and an option is the injection of highly reflective particles at stratospheric levels. To date, injection of sulphuric particles and other minerals have been proposed as viable candidates for SRM purposes. However, injection of these particles could have important effects on stratospheric chemistry through enhanced ozone depletion. Whereas the heterogenous reactions of sulphuric acid particles are well established and understood, this is not the case for other mineral particles. TiO_2 has been suggested as an alternative to sulphate aerosols due to its large refractive index, meaning that less stratospheric aerosol loading would be necessary to achieve the same level of cooling. However, such particles may also affect stratospheric composition through providing a surface for heterogeneous chemistry.

To shed new light on this topic, we have investigated the role of TiO_2 particles to release chlorine radicals via heterogenous reactions at stratospheric levels. Such reactions on sulphate aerosols are a key step in ozone depletion. Two TOMCAT 3D-CTM offline simulations (with and without TiO_2) have been performed to investigate the chlorine activation for time period from 2000-2050, with fixed meteorology and representative volcanic activity of periodic large eruptions. Sensitivity simulations were also performed to test the impact of different reaction efficiencies on TiO_2 particles for reactions involving N2O5, $ClONO_2$ and HCl. We will present results showing the impact of TiO_2 particles on the stratospheric distribution of these species, along with O_3 in a stratosphere of decreasing chlorine loading