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Effects of concurrent stratospheric sulfur geoengineering and a large volcanic eruption

Anton Laakso (1), Antti-Ilari Partanen (1), Harri Kokkola (1), Kari Lehtinen (1,2), and Hannele Korhonen (1)

(1) Kuopio Unit, Finnish Meteorological Institute, Kuopio, Finland, (2) Department of Applied Physics, University of Eastern Finland, Kuopio campus, Kuopio, Finland

Solar radiation management by stratospheric sulfur injection is one of the most discussed geoengineering methods. Injecting sulfur to the stratosphere could be seen as an analogy of large volcanic eruptions, where a large amount of sulfate particles is formed in the stratosphere. These particles reflect solar radiation back to space and thus cool the climate. Effects of stratospheric sulfur injection and large volcanic eruption are both widely studied cases. However effects of large volcanic eruption in case where stratospheric sulfur geoengineering is used has not studied before. This could lead to temporary extra cooling effect when there would be strong radiative forcing from a volcanic eruption and geoengineering.

In this study we use the global aerosol-climate model ECHAM5-SALSA to investigate effects from a case where there is an increased amount of sulfate particles in the stratosphere from both a volcanic eruption and geoengineering. The ECHAM5-SALSA describes aerosol distribution by 10 size bins and calculates the micro-physical processes of nucleation, condensation, coagulation and hydration.

As a baseline, we have studied a case where 8 Tg of sulfur is injected to 20 km height to the equator for geoengineering purposes. On top of that, we have studied volcanic eruptions corresponding in magnitude to the Pinatubo eruption in 1991, where about 8.5 Tg of sulfur was released to the stratosphere. Preliminary results shows that when the eruption takes place in the tropics, the total global radiative forcing from concurrent geoengineering and volcanic eruption is clearly smaller than if the forcing is calculated as the sum of separate cases. Results also show that recovery of the global forcing from volcanic eruption is 2.6 times faster if the eruption takes place in a situation where geoengineering is used. Thus, simultaneous geoengineering and volcanic eruption do not lead to long-lasting extra cooling.

If the volcanic eruption takes place in the Arctic, the global forcing is strongly dependent on the season when the eruption happens. It takes roughly half a year before SO_2 from eruption is oxidized and large enough particles are formed. Thus the global forcing from an Arctic eruption in July is less than half of the forcing from an eruption in January, because in the former case the maximum of efficient reflective particles occurs at the time when there is no significant sun light in the Arctic area.

More specific analysis of how a volcanic eruption could affect geoengineering will be carried out in near future. In addition, the formation, growth and sedimentation of particles from geoengineering and from volcanic eruption will be compared to each other. We will also study how a volcanic eruption and geoengineering will affect cirrus clouds and how stratosphere temperature and dynamics will change when there is a huge amount of sulfate from both volcanic eruption and stratospheric sulfur injection.