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Global warming mitigation by sulphur loading in the atmosphere: Required emissions and possible side effects

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An approach to mitigate the global warming via sulphur loading in the stratosphere (geoengineering) is studied employing a large ensemble of numerical experiments with the climate model of intermediate complexity developed at the A.M.Obukhov Institute of Atmospheric Physics RAS (IAP RAS CM). The model is forced by the historical+SRES A1B anthropogenical greenhouse gases+tropospheric sulphates scenario for 1860-2100 with an additional sulphur emissions in the stratosphere in the 21st century. Different ensemble members were constructed by varying emission intensity, residence time, optical properites, and horizontal distributions of stratospheric sulphates. In addition, starting and ending years of applied emissions are varied between different ensemble members.

Given global loading of the sulphates in the stratosphere, at the global basis, the most efficient latitudinal distribution of geoengineering aerosols is that peaked between $50^\circ N$ and $70^\circ N$. Uniform latitudinal distribution of stratospheric sulphates is slightly less efficient. Sulphur emissions in the stratosphere required to stop the global temperature at the level corresponding to the mean value for 2000–2010 amount $5 - 10\ TgS/yr$ in year 2050 and $> 10\ TgS/yr$ in year 2100. This is not a small part of the current emissions of tropospheric sulphates. Moreover, even if the global warming is stopped, temperature changes in different regions still occur with a magnitude up to $1\ K$. Their horizontal pattern depends on implied latitudinal distribution of stratospheric sulphates.

If the geoengineering emissions are stopped, their climatic effect is removed within a few decades. In this period, surface air temperture may change with a rate of several Kelvins per decade.

The results obtained with the IAP RAS CM are further interpreted by making use of an energy–balance climate model. As a whole, the results obtained with this simpler model support conclusions made on the basis of the IAP RAS CM simulations.