Effect of OCS+O(^{1}D) reaction on OCS disappearance process in the atmospheric sulfur cycle

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A layer of sulfuric acid aerosols (hereafter referred to as SSA: Stratospheric Sulfur Aerosols) is formed in the stratosphere of the Earth's atmosphere. This layer has the property of scattering and absorbing solar radiation, thus fading solar radiation reaching the Earth's surface. Large volcanic eruptions increase the amount of SSA, and solar radiation reaching the earth's surface fades further. And the Earth's surface is cooler due to the faded solar radiation. It is hoped that mimicking this and artificially increasing the amount of SSA will lead to control in global warming. This is geoengineering with SSA. However, if the amount of SSA to be increased is underestimated, the side effects of geoengineering will be magnified. Therefore, a model that can quantitatively calculate the exact amount of SSA is needed.
OCS is the main source of SSA, and OCS disappearance reactions leading to SSA occur mainly in the lower stratosphere. The three main OCS disappearance reactions have been considered to be photodissociation, OCS+OH reaction, and OCS+O(^{3}P) reaction. Therefore, the OCS+O(^{1}D) reaction is not considered in the current atmospheric model. This is because the concentration of O(^{1}D) is lower than that of OH and O(^{3}P) (a difference of at least 10^6 molecules cm^{-3}). However, the rate constant of the OCS+O(^{1}D) reaction determined by Hsin-Tsung Chen et al. (2019) is 4-5 orders larger than that of the OH, O(^{3}P) reaction. Therefore, we can consider that the OCS+O(^{1}D) reaction should also be considered in the atmospheric model. We incorporated the OCS+O(^{1}D) reaction newly into the One-dimensional photochemical model developed by Danielache et al., and run simulations. Then, we analyzed the reaction rates of the above four OCS disappearance reactions.
The analysis shows that the OCS+O(^{1}D) reaction has a contribution of 13% at about 20 km altitude (lower stratosphere), the most important area for SSA production. Therefore, if we won't the OCS+O(^{1}D) reaction when artificially increasing the amount of SSA through geoengineering, an excessive amount of SSA will be needed, suggesting that the quantification of SSA amounts needs to be reviewed.

Keywords: Sulfur cycle, OCS disappearance reactions, Atmospheric aerosol

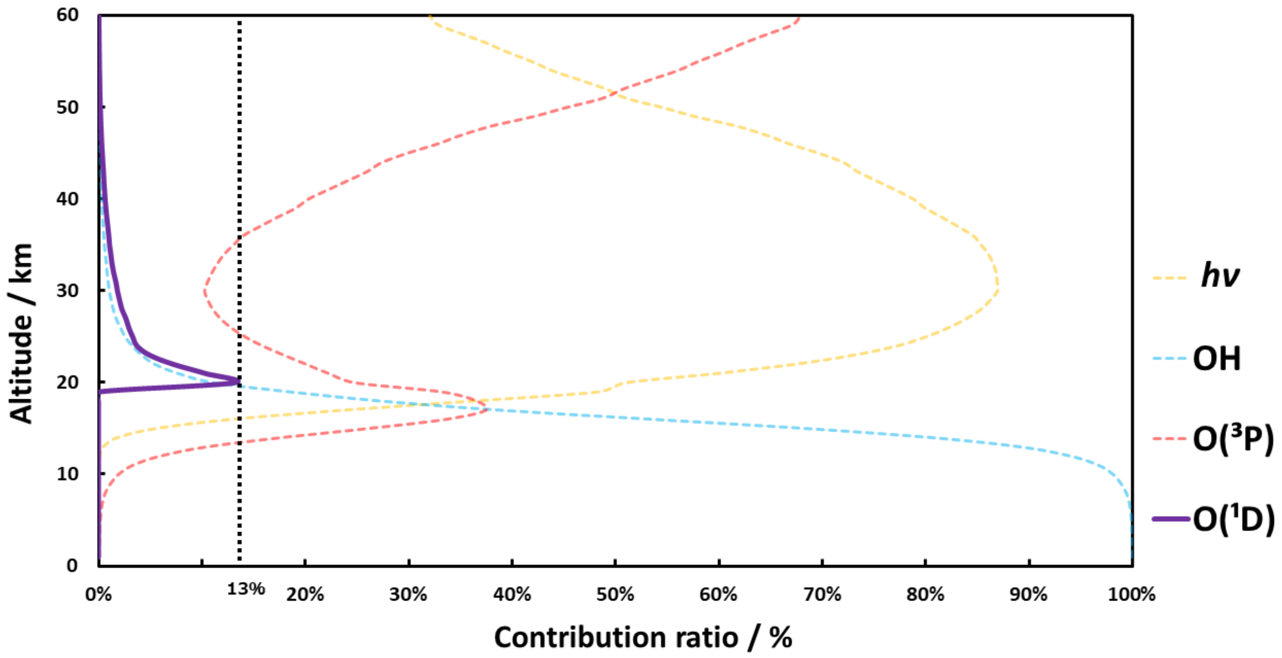

Figure 1. Contribution of each OCS disappearance reaction