Roles of cloud distribution in global atmospheric photochemistry

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Chemical reactions in the atmosphere directly affect formation and loss of ozone, methane, nitrogen oxides, sulfur oxides and aerosols, and have a great influence on the atmospheric environment and climate change. Since these reactions are driven by photodissociation of ozone and related species caused by ultraviolet radiation, they can be largely modulated by distribution of clouds. This study quantitatively investigates the photolytic impacts of clouds on atmospheric chemistry by using a global chemical transport model (chemical climate model) and observational (satellite and aircraft) data.
First, verification with satellite data (ISCCP D2) shows that the model (CHASER) reproduced well the global distribution of cloud amount as in the satellite data.
Sensitivity experiments were also performed to estimate clouds impacts on the photolytic processes and global photochemical field in the atmosphere. As a result, it was shown that OH radical (OH) concentrations decrease by 10 to 20% near the surface and increase by 10 to 20% in the upper troposphere. The changes basically reflect scattering and reflection of solar UV radiation by low-middle clouds, which is consistent with the previous studies. The global mean OH concentration, proxy of the oxidizing capacity of the atmosphere, increased by about 12% due to clouds while the global mean tropospheric ozone (O_3) concentration increased by about 0.7%.
The above results for clouds impacts on the atmospheric chemical field calculated in the model were verified by using aircraft observation (NASA ATOM-1). The result shows that the observed OH and O_3 concentrations are reproduced more accurately when clouds are properly considered in the model.
These results indicate that clouds have significant influences on the global atmospheric chemistry (especially on the OH concentration field). Since OH determines the concentrations of chemical species such as methane, carbon monoxide (CO), fluorocarbons (CFCs), etc. which are important for climate and stratospheric ozone, this study suggests that the variation and trends in clouds can largely affect the chemical species, which may give an additional influence on climate and atmospheric environment.

Keywords: Cloud, Chemistry-transport model, Ozone, OH radical

