Geophysical Research Abstracts
Vol. 18, EGU2016-11627, 2016
EGU General Assembly 2016

Aerosol nitrate from lightning - from sources to impacts

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Particulate nitrate is a key component on the inorganic atmospheric aerosol composition. Due to its semi-volatility, an accurate description of the budget and the impacts of nitrate aerosol are still somewhat uncertain. To address some of the impacts of nitrate, in this study we explicitly analyse the impact of aerosol nitrate from a natural source, namely lightning. As the lightning NO_x emissions are only a contribution to the total NO_x emissions, this example does not resemble a typical annihilation scenario, which might substantially misjudge the effect of aerosol nitrate due to the high non-linearity in the nitrate budget, but also other directly connected compounds, but tries to shed light onto the sensitivity of aerosol nitrate and its effects.

On the other hand, lightning represents an emission source of NO_x, which is partly injected directly in the upper troposphere, where due to its longer lifetime and the temperature dependent stability of NH_4NO_3 aerosol nitrate can form much easier and has a longer lifetime against decomposition.

This study uses a comprehensive chemistry climate model to track the evolution of aerosol nitrate from the lightning NO_x emission, via chemical processing and gas-aerosol partitioning, aerosol microphyiscal processes down to the climatic impacts of the nitrate aerosol particles via direct aerosol-radiation and aerosol-cloud interactions. All of these processes are explicitly considered with the help of state-of-the-art (parameterisation) schemes, including a comprehensive multi-phase chemistry configuration, a microphysical and chemical composition aerosol model, aerosol optical properties and a two-moment cloud microphysical scheme with explicit activation of aerosol particles into cloud droplets and the consideration of aerosol particles in ice formation processes. Furthermore, some uncertainty with respect to cloud droplet formation has been considered by using two different aerosol activation schemes. To estimate the relative impact of anthropogenic influence, scenarios for both anthropogenic and pre-industrial conditions have been considered.

The direct aerosol-radiation interactions are relatively small, whereas the effects associated to modifications in clouds and their optical properties dominate the overall climate impact.