Geophysical Research Abstracts
Vol. 20, EGU2018-5943-2, 2018
EGU General Assembly 2018

Secondary aerosol formation promotes water uptake by organic-rich wildfire haze particles in Equatorial Asia

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Peatland fires in Equatorial Asia, which can keep smouldering even for months, have been recurrently occurring during the last few decades. Aerosol particles emitted from these combustions have been influencing both climate and environment. For instance, particles originating from the peatland fire in 1997 were reported to have resulted in dramatically cooling effects on the atmosphere radiative budget, especially over the source region of Indonesia (-150W m^{-2}) and the tropical Indian Ocean (-10W m^{-2}) (Duncan et al., 2003). The recent 2015 Indonesian wildfire event could rival the one in 1997 in terms of not only hazardous to human health but also the significant impacts on global climate. These regional and global impacts are closely tied to aerosol hygroscopic properties, which could dramatically alter aerosol physical and chemical characteristics. However, hygroscopic property of Indonesian wildfire haze particles has been rarely investigated.

In this study, we explored the relationships between water uptake properties and chemical composition of wildfire haze particles by conducting atmospheric observations at Singapore in October 2015 during a pervasive wildfire haze episode, stemmed from peatland burning in Indonesia. Diameter growth factors (GF) of 100 nm haze particles at 85 % relative humidity and chemical characteristics were simultaneously monitored. Non-refractory submicron particles (NR-PM1) were dominated by organics (approximating 77 % in total mass), whereas sulfate was the most abundant inorganic constituent (12 % on average). A statistical analysis of the organic mass spectra showed that most of organics (36 % of NR-PM1 mass) were highly oxygenated. Diurnal variations of GF, number fraction of highly hygroscopic mode particles, mass fraction of sulfate, and mass fraction of oxygenated organics (OOA) synchronized well, peaking during daytime. The mean hygroscopicity parameter (κ) of haze particles was 0.189 $\pm$ 0.087, and mean κ values of organics were 0.157 $\pm$ 0.108 (κorg, bulk organics) and 0.287 $\pm$ 0.193 (κOOA, OOA), demonstrating the important roles of both sulfate and highly oxygenated organics in hygroscopic growth of wildfire haze particles. These results show the importance of secondary formation processes in promoting water uptake properties of wildfire haze particles, including both inorganic and organic species. Further detailed size-resolved as well as molecular level chemical information of organics will be necessary for more profound exploration of water uptake by wildfire haze particles in Equatorial Asia.