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The main controlling factor of black carbon mass concentration in rainwater during 2010-2013 summer in East Asia

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Black carbon (BC) particles are emitted into the atmosphere by incomplete combustion processes, and removed by precipitation. The measurements of BC mass concentration in rainwater improve the quantitative understanding of BC loss because wet deposition is the major sink of BC. We measured BC mass concentration in the air (M_{BC}) and in rainwater (C_{BC}) simultaneously at Cape Hedo on Okinawa Island, Japan, in the East China Sea, from April 2010 to March 2013 in order to understand C_{BC} in each rain event during 2010-2013 summer. The rainwater is collected by an automated wet-only sampler during a 24 period. Photo-absorption photometer with heated inlet (COSMOS) is used to measure M_{BC}. C_{BC} was measured by a system consisting of an ultrasonic nebulizer and a Single Soot Photometer (SP2).

It is often heavy rain by cumulonimbus cloud during summer in East Asia, so that M_{BC} an hour before raining is expected to be related to C_{BC}. However, the correlation between M_{BC} and C_{BC} in all rain events during 2010-2013 summer is not agreed ($r^2 = 0.12$). Then, we extracted the heavy rain events, which had positive convective available potential energy (CAPE). These extraction was performed with the National Centers for Environmental Prediction (NCEP) Final (FNL) Operational Global Analysis data every 6 hours. This result was that C_{BC} was correlated with M_{BC} ($r^2 = 0.47$).

In order to investigate if C_{BC} (Estimated C_{BC}) is explained with M_{BC} and the liquid water content, Estimated C_{BC} is verified by comparing the observed C_{BC}. The liquid water content is maximum at the equilibrium level (EL) by the condensation process theoretically if the total water mixing ratio is conserved in the air parcel. If BC in the parcel is active as cloud condensation nuclei (CCN) at lifted condensation level and removed by precipitation at EL, the equation of Estimated C_{BC} at EL is represented as Estimated $C_{BC}=M_{BC}/(m_v*WCR)$. m_v is the water vapor content an hour before raining at the ground level. Water condensation ratio (WCR) is the mass ratio of liquid water content to water vapor content, which is calculated with the NCEP reanalysis data. Compared with the observed C_{BC}, Estimated C_{BC} is correlated with the observed C_{BC} well ($r^2 = 0.68$). It suggests that Estimated C_{BC} is correctly represented as C_{BC} with M_{BC} and the most liquid water content at EL. The observed C_{BC} is three times higher than Estimated C_{BC} because the cloud droplets including BC particles might be collected during falling down.

Keywords: Black Carbon, wet deposition